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Jordan

INDIANA.

DEPARTMENT

OF

Geology and Natural History

DEPARTMENT OF
GEOLOGY AND NATURAL HISTORY,
INDIANAPOLIS, IND.
JOHN COLLETT, *State Geologist.*
PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.
n return, scientific books, fossils, etc., and implements of the "stone age" are acceptable.

1881.

INDIANAPOLIS:
WM. B. BURFORD, STATE PRINTER.
1882.
H

LIBRARY
OF THE
LELAND STANFORD JUNIOR
UNIVERSITY.

A. 55.

STATE OF INDIANA,
OFFICE OF THE STATE GEOLOGIST,
INDIANAPOLIS, MARCH 10, 1882.

HON. ALBERT G. PORTER,
Governor of Indiana:

Herewith I have the honor to submit to your Excellency the eleventh annual report of the State Geologist, being for the year 1881; it comprises the labors of that officer and assistants in the field, study, and cabinet, with detail surveys of the Counties of Shelby, Fountain, Delaware and Bartholomew, a statement of facts as to building stone, coal and clays, with full paleontological descriptions, etc., of the Niagara fossils of the Waldron beds, and other characteristic corals and fossils of the State, illustrated by fifty-five plates, maps, etc.

With high esteem, I remain your obedient servant,

JOHN COLLETT,
State Geologist.

STATE OF INDIANA,
GOVERNOR'S OFFICE.

Filed with the Governor, March 10, 1882. Examined and transmitted to the Secretary of State, to be preserved in his office and published, according to law, under the direction of the Commissioners of Public Printing.

F. H. BLACKLEDGE,
Private Secretary.

Filed in my office March 10, 1882,

E. R. HAWN,
Secretary of State.

LAW ESTABLISHING THE DEPARTMENT.

AN ACT to provide for the establishing of a Department of Geology and Natural History in this State.

[APPROVED APRIL 14, 1881.]

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That a Department of Geology and Natural History is hereby established for the purpose of continuing the geological and scientific survey of this State, of discovering and developing its natural resources, and disseminating information in regard to its agricultural, mining and manufacturing advantages.

SEC. 2. That the Governor shall appoint a competent and suitable person, who shall be skillful in geology and natural science, as State Geologist, and who shall be the chief of said department; and said chief shall have power and be authorized to call to his assistance such help as he may deem necessary, but in no case to exceed the amount of expenditure authorized by the General Assembly. Said State Geologist, when commissioned by the Governor, shall take an oath of office as other officers, and shall serve for a term of four years; but said State Geologist may be removed by the Governor for cause, and a successor appointed in his stead, and the Governor shall fill any vacancy which may occur from any cause. The compensation of said State Geologist shall be eighteen hundred dollars per year, which shall be paid as other salaries are required by law to be paid.

SEC. 3. It shall be the duty of said State Geologist to continue the geological survey of the State, by counties or districts, and to complete and revise the same as may be practicable. He shall give special attention to the discovery of minerals, stones, or other natural substances useful in agriculture, manufacture or the mechanical arts; he shall be curator of the geological cabinet, museum, apparatus and library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains and other objects of natural history peculiar to this State and other States and countries.

SEC. 4. The offices of the geological department shall be in such rooms as may be assigned for this purpose, and he shall keep such office and the State museum open during the usual business hours of other offices of State, when not engaged in field or other work requiring his absence therefrom.

SEC. 5. The State Geologist shall make to the Governor an annual report of his labors and discoveries, and of all useful information he may have obtained in such service, including such descriptions and figures in geology, paleontology and archæology as may promote science and aid in the diffusion of knowledge; and five thousand copies of such report shall be printed and published in like manner as other official reports.

SEC. 6. An appropriation of five thousand dollars annually shall be, and is hereby, made for the next succeeding two years, which shall include the salaries of the State Geologist and his paid assistant, and if any part thereof shall remain unexpended, it shall remain a part of the general fund of the State, to be used as other general funds of the State are used.

SEC. 7. All acts and parts of acts inconsistent herewith are hereby repealed.

SEC. 8. Whereas, an emergency is hereby declared to exist for the immediate taking effect of this act, it shall, therefore, take effect and be in force from and after its passage.

ORGANIZATION AND WORK.

Pursuant to the foregoing act of the Legislature, on the 26th day of April, 1881, John Collett was commissioned State Geologist, qualifying on the 28th of April.

Immediate measures were taken to begin active work. The property, library, chemical laboratory etc., properly belonging to the Bureau of Statistics, was turned over to its chief.

Additional cases were procured through funds appropriated for geological purposes, in the hands of the State Board of Agriculture, and Mr. George K. Greene was engaged to arrange the fossils and specimens in their proper cases.

This duty has been discharged with care and laborious effort. The specimens are determined, prepared and labeled, offering an instructive book of natural science to the amateur, student or teacher.

The cabinet, when first received from my predecessor, by actual enumeration, consisted of 8,912 specimens, mostly undressed fossils, generally without labels.

At present it embraces, well arranged, properly classified and labeled:

Former collection, specimens	8,912
Collected, etc., 1880	11,647
Total 1880	20,559
Collected by State Geologist and assistants in 1881	5,500
Purchased, Crinoids	375
Purchased, fossil corals, shells, etc	9,750
Purchased, beetles, about	1,700
Purchased, land and fresh water shells	5,800
Donated, fossils	520
Donated, Indian stone relics	140
Donated, miscellaneous	80
Grand total 1881	44,424

There is now on exhibition a pretty full set of germs,* minerals* and crystalline rocks,* implements of the "Mound Builder," or "Stone Age;"* fishes and reptiles of Northern Indiana; land and fresh water shells, and beetles; fossils of the coal measures and lower carboniferous periods. In fossils of the Lower Silurian, Upper Silurian and Devonian ages, the collection is a nearly complete exhibit of the specimens peculiar to the State, and may not be readily excelled.

Most of the specimens are carefully labeled, the collection thus affording the student or teacher a wide view of the Indiana pages of the book of nature.

It is gratifying to know that the great facilities thus placed within the free reach of our people, for education in important branches of science, are fairly appreciated. From five to fifty persons, from different parts of the State, have visited the rooms daily during the past year, expressing, in warm and complimentary terms, their gratification.

Specimens of coals, clays, building stones, etc., the products of the State, are on exhibition, and in many instances have been the means of causing the sale of such minerals and materials, within and without the State, in aggregates amounting to hundreds of thousands of dollars, thus demonstrating the value of scientific exhibits as to economic results.

The interest manifested in the museum by citizens and strangers who visit it is constantly increasing. In order to fully meet expectations and to do justice to the natural resources of the State, it is thought that the museum and cabinet should be largely increased; that a complete show of stones, clays, minerals, woods, and other products, as well as specimens in natural history, should be accessible to citizen and visitor, student and teacher, with a competent, permanent, director, expert in matters pertaining to his department, capable of imparting freely such advice or information as would tend to show forth the advantages, natural or acquired, of Indiana.

Additions to the museum should be continued until the resources of the State are represented in such manner as to be readily studied in these public rooms. The array is already large, representing in collections, donations, and by purchase, the labor of more than sixty years, and may thus be fairly estimated at nearly as many thousand dollars in value. Although the actual cost has been small or insignificant, it may be safely assumed that equal additional purchases will require much larger expenditures.

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*Deposited by citizens for exhibition.

Any action of the Legislature looking to the maintenance of such a department, and increased collections of specimens, would most unquestionably meet the approval of our people, and be of great benefit not only to individuals, but to the State at large.

Ryland T. Brown, a pioneer in scientific researches, and formerly State Geologist, made a detailed survey of Fountain county with the vigor and energy so characteristic of the man. His habits of close observation, and long experience, have enriched his report with facts and valuable suggestions.

Moses N. Elrod makes the survey of Bartholomew county. His former labors in geological work may be seen in his report on Orange county in previous years.

A. J. Phinney's report on Delaware county, exhibits the geological features of that county, especial attention being given to surface geology.*

By the act of the Legislature the Professor of Chemistry at Purdue University was made State Chemist, and all chemical questions were by law referred to him and the Professor in Chemistry at Bloomington University, the Legislature deciding that the laboratories at those institutions, kept up with public funds, were sufficient, relieving this department of analytic duty.

John N. Hurty, analytic chemist of Indianapolis, has continued as special chemist to the State Geologist, and has discharged his duty with precision and faithful care.

Prof. James Hall, State Geologist of New York, with the generous spirit characteristic of such princely leaders in science, granted the privilege of republishing his figures of "Waldron Fossils" of Indiana (32 plates), which were given in the Twenty-eighth Report of the Regents of the New York University, but so rare and inaccessible to our teachers and students that but few copies are known to be owned by our citizens. He has revised the descriptions and supplemented his former labors, by adding four plates (lithographed), with descriptions of new fossils of the same locality, making the reports on these beds fully up to the latest developments of the day. The high scientific, world-wide reputation of Professor Hall, his life-long labors as a pioneer in geology, investigator and educator, enriched by the widest experience, makes his work of the highest value to Indiana.

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*Assistants are wholly responsible for facts, etc, in their respective reports.

Dr. Charles A. White, Paleontologist to Government Surveys at Washington, has generously continued his review of characteristic fossils of the different geological formations of the State with figures of new fossils, illustrated in seven plates. To this he has added a review and description of a part of the Van Cleve figures, kindly furnished by Dr. Julius S. Taylor, of Kankakee, Ill.

Dr. White's experience as a teacher, and in field work, makes his introductory remarks of special interest and value, and it is believed will be highly appreciated.

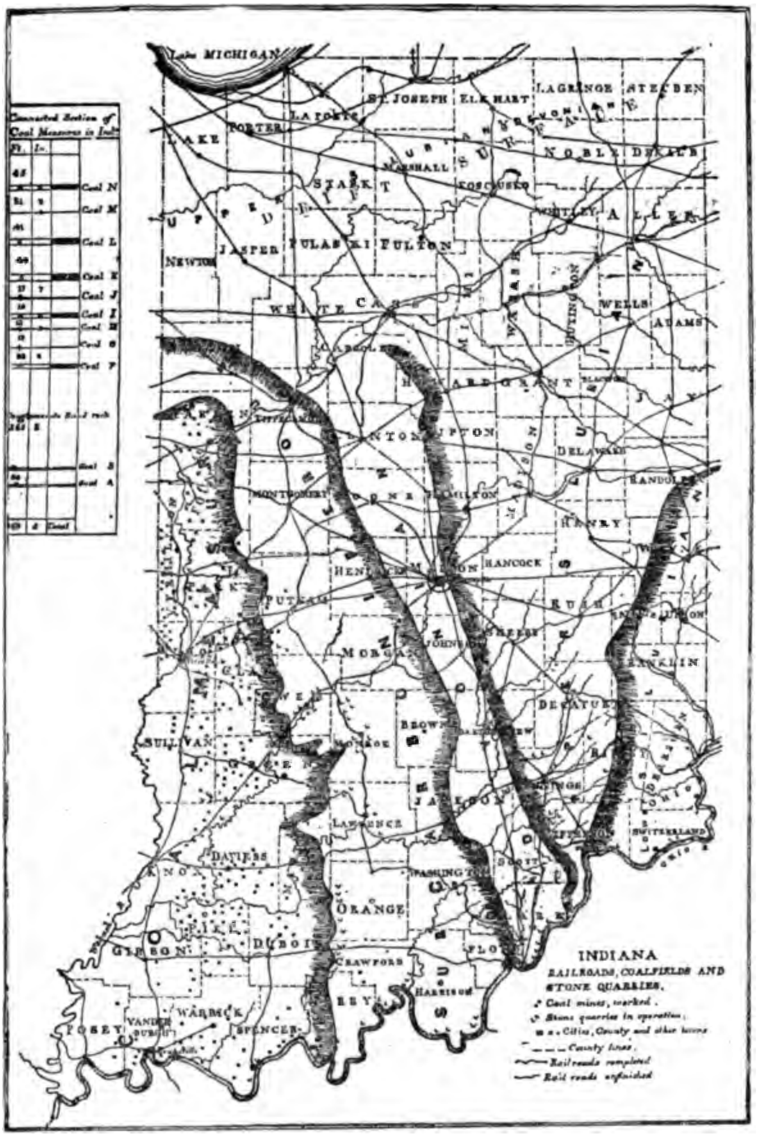
The plates number from one to fifty-five, comprising several hundred figures, and, as far as they go, well illustrate the paleontology of the State, and will, it is trusted, prove "an addition to knowledge among men." It is the first considerable attempt at illustration of paleozoic life by Indiana. Heretofore our students who desired to know the geology of their *own State* were compelled to purchase the geological reports of other States; but few young or old men had spare funds to make this costly investment. The experiment now made in this report is to test the question for the future. If students and teachers wish such reports continued, or improved, they must call on their legislators to so provide. If they do not so call, they may and should cease. The preparation of the paleontological work has been at a minimum expense; much less than can be depended upon for the future. Such work may and should be conducted at a fairly remunerative outlay for labor and skill, and the Legislature should be induced to appropriate the necessary means.

The State Geologist has had general direction of the work, arranging for the assistance of experts in the field and in the cabinet, and in addition to many local examinations has made a detailed survey of Shelby county, herein given.

He has almost daily had consultations with persons interested as to facts in agriculture, quarry industries, coal mines, and the use of these materials; drainage, water supply, etc. The correspondence of the office, under his sole care, has amounted during the past year to 1,020 letters, many of which were for information as to costly and important enterprises, requiring thoughtful care.

Thanks are returned to the officers of railways and transportation companies for favors to the State Geologist and his assistants on field work; to citizens for hospitality, information, guidance, and hearty co-operation; to scientists of the State, of the United States, of the whole earth, for contributions to the State Museum and Library, especially the several departmental surveys at Washington. A continuance of these favors from every citizen of Indiana is respectfully solicited.

OUTLINE GEOLOGICAL MAP OF INDIANA.



GEOLOGY OF INDIANA.

The outline geological map of the State, printed herewith, is upon so small a scale that it must be regarded as merely a rough sketch. It shows, however, with reasonable accuracy, the surface exposures of the rocks of the several geological formations. An extended description of each of the general strata with a section illustrating the same might have been advantageously added to the present report, but circumstances permit of only the following brief statement, embracing a list of the counties in which the several strata are found.

LOWER SILURIAN.

The rocks of the lower Silurian age, known as the Hudson river or Cincinnati group, are found in the southeastern division of the State, extending also throughout large areas in Ohio and Kentucky. They are well exposed in the bluffs of the Ohio river, extending west to the mouth of Fourteen-mile creek, in Clark county, and form the surface rocks in the counties of Wayne, Union, Fayette, Franklin, Dearborn, Ohio and Switzerland. In several of the adjoining counties to the west are exposures of lower silurian in ravines and deep cuts, as on the extreme east side of Clark, Jefferson, Decatur, Rush, and in the eastern part of Randolph counties. The rocks of this formation are filled with well-preserved fossils, and in decomposition form a rich and highly productive soil.

UPPER SILURIAN.

Strata of the upper Silurian formation form the general surface rocks of the counties immediately west and northwest of those in the lower Silurian, including Adams, Wells, Washington, Wabash, Miami, part of Jasper, White, Cass, Jay, Blackford, Grant, part of Howard, Delaware, Madison, the eastern parts of Tipton and Hamilton, Randolph, Henry, Hancock, Rush, Shelby, Decatur, the eastern part of Marion, Bartholomew, Jennings, Jefferson and the eastern parts of Scott and Clark counties. The upper Silurian strata also extends north and northwest from these counties to the northern boundary of the State, at many points being locally capped by uneroded areas of Devonian age, but the Silurian is so deeply covered with bowlder drift as to be rarely seen, and its presence is more known by test bores than by outcrops in the drift district.

Soils derived from the disintegration of rocks of this age are, as a rule, cold, heavy clays, which, when drained, produce good crops of wheat and the grasses.

DEVONIAN FORMATION.

The Devonian rocks are exposed in a narrow band, commencing on the south of the central parts of Clark and Floyd counties, and extend thence north and west through the counties of Scott, Jackson, Bartholomew, Johnson, Marion, Boone, Clinton and Carroll, with local exposures in Tippecanoe, Cass, White and Jasper, parts of Shelby, Decatur, Delaware and Rush. From fossils collected in the drift area to the north and west, and from test bores, it is known that Devonian rocks have been more or less eroded, but once covered much of the northern third of the State, and at many points they are still in place.

SUB-CARBONIFEROUS OR MOUNTAIN LIMESTONE.

Rocks of the sub-carboniferous series form the surface strata in a wide belt west of the Devonian and east of the coal measures, and these, for the most part, constitute the rocky exposures of the counties of Harrison, Crawford, Orange, Washington, Lawrence, Brown, Monroe, Owen, Morgan, Putnam, Hendricks, Montgomery, Tippecanoe and Benton. The eastern line of this belt is composed of shales and sandstones of the Knobstone group, while adjoining on the west are the great cavernous limestones of the State, so well exhibited in the southern counties, but which thin out to a few feet at the north. The soil of this district is remarkable for its growth of cereals and grasses.

COAL MEASURES.

The rocks of the coal measures are found in the counties of Posey, Vanderburgh, Warrick and Spencer, the Western parts of Perry and Crawford, in Gibson, Pike, Dubois, Knox, Daviess, Martin, Sullivan, Greene and Clay, the western part of Owen, and in Vigo, Parke, Vermillion, Fountain and Warren.

It is apparent, therefore, that the lower Silurian, being the oldest rocks brought to the surface, underlie all the more recent rocks which in succession have been deposited during the different ages of the earth's existence. A shaft or bore put down in the western part of Gibson county would pierce in succession all the geological formations of the State, and would show the approximate depth of each to be as follows:

General Section.

Coal measures	725	feet.
Sub-carboniferous	680	"
Devonian	200	"
Silurian	3,000	"
Total	4,605	"

MINES AND QUARRIES.

MINERAL COAL.

The coal mines of Indiana, although their development has only begun, is of high economic interest; the production has been limited to the demands of a new country with few factories, but the promise for the future from these treasure houses is grand. Our coal field embraces an area of nearly 7,000 square miles, offering a total of twelve seams at a depth ranging from nought to three hundred feet, and averaging eighty feet below the surface. Five of these seams, wherever met, are almost constantly workable, varying from two and a half to eleven feet, averaging four and a half feet in thickness; five other seams are mined at occasional favored localities; two minor coals are only worked by stripping for local use. The quality is fair to choice, as shown by analyses and tests in former geological reports.

"Block" or splint coal prevails in an area of six hundred square miles, which is used in the blast furnace, as it comes from the mine without cokeing. This Indiana block coal is of superior quality, rich in carbon, remarkably free from sulphur, ash and phosphorus, and well suited for manufacture of Bessemer steel and the highest metallurgic processes. It burns without cokeing, in a ruddy flame, like hickory wood, to a minimum of white ash. The cokeing coals furnish an excellent fuel for house, factory, mill or locomotive use. The abundance of coal and ease of access cheapen this fuel. It may be had in large lots on every line of railway at from five to ten cents per bushel, or at from $1.50 to $2.80 per ton.

The survey is indebted to report of R. Pumpelley, Special Agent of Tenth United States Census, for the following details of our mining industries for the census year:

Statistics of Indiana Coal Mines, 1880.

Number of counties with mines opened	19
Number of establishments	216
Maximum capacity of yearly production, tons	3,110,183
Product of same, tons	1,449,496
Value of product at mines	$2,143,093
Irregular product local strip-banks, tons	4,831
Total product, tons	1,454,327
Value of total product at mines	$2,150,258
Value of materials used in mines	$158,604
Wages paid to all classes of labor	$1,405,164
Men employed above ground	570
Men employed below ground	3,748
Boys, under 16, employed above ground	7
Boys, under 16, employed below ground	171
Total employes	4,496
Number of steam engines employed	65
Horse-power of steam engines	1,717
Value of all machinery, including engines	$146,908
Value of explosives used	$56,151
Amount employed as working capital	$348,665
Value of mining plants	$773,445
Value of real estate	$1,146,859
Total capital employed and invested in establishments	$2,268,969
Tons paying royalty	899,356
Amount paid as royalty	$137,311
Acres of coal land worked out	2,884
Acres of land unworked, attached to works	8,000
Acres of mining land unspecified	2,407
Total capital in establishments and irregular workings,	$2,304,720
Acres available coal lands attached to working establishments	10,407
Average price per ton of product of regular mines, at mine	$1 48
Average cost of labor per ton	$0 97
Average cost of material, per ton	$0 11
Average amount left for royalty, profit, etc., per ton	$0 40
Per cent. of capital used for working capital	15.37

Per cent. of capital in plant	34 09
Per cent. of capital in real estate	50 54
Average royalty paid, per ton	$0 15
Average yearly earnings of man, net	$318 85
Average per cent. of year worked	74.34
Average per cent. of year idle, except from strikes	21.36
Average per cent. of year lost by strikes	4.30
Tons raised per man per day	1.47
Tons raised yearly per man	328.91
Per cent. ratio of product to maximum capacity	46.59

One Hundred Indiana Coal Mines Classified on the Basis of the Power Used.

Class 1. Mines using no power to supplement manual labor.
Class 2. Mines using the power of animals only.
Class 3. Mines using boiler-power not exceeding 100 horse-power.
Class 4. Mines using boiler-power exceeding 100 horse-power.

CLASS.	Number of mines in class.	Aggregate maximum yearly capacity, net tons.	Product census year, net tons.	Value of census year's product at mines, in dollars.	Average yearly product, net tons per mine.	Average value per ton at mine.	Average cost of labor per ton mined.	Average number of days worked by each man.	Average earnings per man, census year.	Average per diem wages earned.	Average product per man per day worked, net tons.	Average horse-power to mine.	Tons mined per horse-power yearly.	Per cent. of value of product paid for labor.	Per cent. of value of product paid for materials.	Per cent. of value of product for profits, including interest, repairs, and royalty.	Average number of hands to mine, all classes of labor, including sup'tendence.
1.	12	42,808	9,807	13,291	817	1 35	87	162	$202 00	$1 25	1.44	. . .	. . .	64	5.0	31.0	3.5
2.	36	430,082	143,657	214,924	3,991	1 50	84	155	244 00	1 57	1.88	2.4	1,663	56	14.6	29.4	13.7
3.	48	2,000,000	1,144,243	1,705,166	23,839	1 49	97	230	346 00	1 50	1.55	44.0	592	65	7.0	28.0	67.0
4.	4	314,820	122,617	186,704	30,654	1 52	1 11	246	404 00	1 64	1.48	153.0	200	73	7.0	20.0	84.0
Total	100	2,787,710	1,420.324	$2,120,035	14,203	$1 49	$0 97	222	$337 00	$1 52	1.56	28.1	505	65	7.8	27.2	40.9

"These tables illustrate, in a general way, the proposition that large mining establishments, which employ power and labor-saving machinery, can pay higher wages and give more steady employment to labor than smaller ones. The mines chosen in this State were typical ones of their classes. The large amount spent for 'materials' by Class 2 is, to a great extent, made up of feed, etc., for the animals used.

"As a general rule, too, the mines employing capital most liberally can afford to yield to labor a larger share of the value of the product, since their profits depend on the volume of their business. They also employ more skilled labor. It is believed that these features run through the entire mining industry."

Rank of the States East of the 100*th Meridian, Producing Bituminous Coal in the Census Year ending June* 1, 1880.

Number.	NAME OF STATE.	Product of Regular Mines, Tons of 2,000 Pounds.	Percentage of Total Product.	Number.	NAME OF STATE.	Product of Regular Mines, Tons of 2,000 Pounds.	Percentage of Total Product.
1	Pennsylvania . . .	18,004,988	44.665	11	Tennessee	494,491	1.227
2	Illinois	6,089,514	15.107	12	Alabama	322,934	0.801
3	Ohio	5,932,853	14.718	13	Georgia	154,644	0.383
4	Maryland	2,227,844	5.527	14	Michigan	100,800	0.250
5	West Virginia . . .	1,792,570	4.447	15	Virginia	40,520	0.100
6	Indiana	1,449,496	3.596	16	Arkansas	14,778	0.036
7	Iowa	1,442,333	3.578	17	Nebraska	200	. . . .
8	Kentucky	935,857	2.322	18	North Carolina . .	250	. . . .
9	Kansas	763,297	1.894		Total	40,311,459	100.00
10	Missouri	543,990	1.349				

Rank of States East of the 100*th Meridian, as Producers of Bituminous Coal, according to the Census of* 1870.

		Per cent. Gain in 1880.
1.	Pennsylvania	131
2.	Illinois	132
3.	Ohio	135
4.	Maryland	22
5.	Missouri	13

		Per cent. Gain in 1880.
6.	West Virginia	194
7.	Indiana	231
8.	Iowa	447
9.	Kentucky	521
10.	Tennessee	270
11.	Virginia	34
12.	Kansas	2,217
13.	Michigan	258
14.	Alabama	2,836

"The United States, exclusive of the territories, has gained 134.4 per cent. in weight of product. The average price per ton has fallen from $1.99 to $1.22 during the past decade, the price for 1870 being, of course, reckoned in paper dollars."

It was intended in this report to give a review of the coal industries of the State, repeating analyses given in former reports of the State Geologist, which have done so much to advance the commerce, manufactures and wealth of our people, but a short appropriation forbids the publication of this and other articles which are with reluctance omitted. Although our coal fields are but partly developed by access of railways, and the demand, constantly growing, is but in its infancy, Indiana will take pride in the fact that the coal out-put has increased in the last decade 231 per cent., or at the handsome rate of over 23 per cent. per annum, and she ranks as the sixth State of the Union in the production of coal.

CLAYS.

The beds of fire clay which underlie the coal seams are more persistent than the coals themselves. This material, which will be of great importance for door and window casing, cornices, etc., in the buildings of the future, when common safety will require fire-proof houses, is sufficiently abundant to supply the world, and can be cheaply mined after the coal is removed. Some of the clays are aluminous, offering choice material for sewer pipes, pumps, jars and terra cotta products; others are highly silicious, suitable for fire-brick, retorts, etc. At several localities they are modified by the sorting process of water in motion and well adapted for common crockery and tiles.

The Kaolin mines of Lawrence county are filling a considerable demand from eastern cities, and contribute in enabling the Encaustic Tile Works of Indianapolis to rival the most famous tile workers of Europe. The excellence, superiority of the fabrics of this company is largely due to special clays of this State. The demand for their product is up to the full capacity of their works, and successfully meets with full competition in the cities of New Orleans, Washington, Philadelphia, New York and Boston, the flooring tiles of the world.

BUILDING STONE.

QUARRY INDUSTRIES.

Fifty years ago much of the territory constituting the State of Indiana was a wild, pathless forest or prairie solitude, the home of wild beasts and a few tribes of wilder savages. These obstacles to civilization had to be removed. Pioneer life was heroic. Constant watch and ward a duty. The rifle, knife, axe and brave hearts were necessaries of life to the farmer, artisan and housewife. Prairie and forests have been largely subdued, and the present is a high realization of the harvest planned by our fathers.

The first houses, towns, cities, bridges, even roads were built from the superabundant trees, and until within a few years no other material was required or sought. Now, that profitable tillage has removed in a large degree the encumbering forests, other building materials, as brick, clays, stone, etc., are demanded. In obedience to this call nature presents stone, easily accessible and well suited to use.

In the southeastern lower Silurian region, stone for foundations, rubble masonry is obtained from beds of that age.

Bordering to the west the close-grained, compact magnesian limestones occur, and are extensively mined in a belt extending from the Ohio on the south, northwardly across the State to the Wabash in Huntington, Wabash, Miami, Cass and Carroll counties, and to some extent in other counties north and west where generally the rocky substratum is deeply covered with drift. This Upper Silurian stone is in even beds, from a few inches to two or more feet in thickness, and meets a full demand for foundations, piers, abutments, and massive range work, where great strength is required. A stone offering, as this does, at the quarry, two sides ready for the mortar bed, commands the attention of the economical builder. Thinner strata yield slabs, flags, curbs, etc., at cheap rates.

The "North Vernon Blue Limestone," of Devonian age, covers an extended area in Jennings and Jefferson counties, and is well known to engineers and bridge builders. In some districts to the south of Vernon and Deputy these beds become aluminous, and possess hydraulic properties.

The quarry rocks of the lower Carboniferous period form the surface rock, from Warren county, on the north, to, in a widening belt, Ohio river on the south. Limestones of the Keokuk, sandstones of the Chester, and Oolitic limestone of the intermediate St. Louis group, present a great variety of valuable features. The Oolitic stones will be specifically mentioned hereafter.

In the coal measure area a variety of sandstones are quarried and used. The basal conglomerate sand rock extends in a broad belt from Warren county to Ohio river, and offers an unlimited amount of strong, fire, frost and water proof stone, suitable for foundations, piers, etc.

The following table, by favor of Superintendent of United States Census, shows the quarry industries of the State in this their beginning or infancy:

Table indicating the Amount and ***Kinds***

LOCATION OF THE QUARRY.	COUNTY.	NAME OF THE CORPORATION, COMPANY OR INDIVIDUAL.	SPECIFIC VARIETY OF STONE.		Color.
			Popular Name.	Scientific Name.	
Decatur.	Adams.	B. P. Rice.	Limest'e	Dolomite.	Drab
Bluffton.	Wells	Kapp & Gardner	"	"	"
Wabash.	Wabash	Bridges & Scott	"	Limestone	"
"	"	Hubbard & Smith	"	"	"
"	"	Philip Hipskin	"	"	"
"	"	Wm. J. Ford	"	"	"
"	"	Moellering & Paul	"	Dolomite.	"
"	"	Lillie & Shoemaker	"	Limestone	"
Logansport.	Cass	Lux & Lux	"	Limest'e, Dolom	"
"	"	J. E. Barnes	"		Gray
"	"	August Gleitz	"		"
3½ mils S. W. Kokomo	Howard	J. V. Smith	"	Mag. Limestone	Drab
Kokomo	"	Geo. W. Defenbaugh	"	Limestone	"
Marion	Grant	D. R. McKinney	"	Mag. Limestone	"
"	"	Silvester Fankboner	"	" "	"
"	"	John Murphy.	"	" "	"
Montpelier	Blackford	Wm. Twibell	"	Dolomite.	"
Eaton.	Delaware	Geo. W. Carter	"	"	"
"	"	Bosman Brothers.	"	"	"
Yorktown.	"	L. D. Koontz	"	"	"
Anderson	Madison	William Crim	"	Mag. Limestone	Gray
"	"	J. W. Sansberry	"	" "	"
Greencastle.	Putnam	Patrick Ash	"	Limestone	Drab
2 ms S.W. Greencastle	"	Williams Steegs	"	"	"
2 " " "	"	A. J. Crawford	"	"	"
2 " " "	"	Vandalia Railroad Co	"	"	"
Okalla	"	Moss & Hillis.	"	"	"
"	"	Torr & Brother	"	"	"
Putnamville	"	James Lee	"	Siliceous l'stone	"
Longwood	Fayette	Wilson Ball	"	Fer'ginous Dol.	Drab and buff
"	"	R. H. Moffitt	"	" "	" " "
2¾ miles N.W. Laurel, Franklin county	"	H. Reese	"	Dolomite	Drab
2¾ " W. Laurel	Franklin.	M. E. Secrest.	"	"	"
2½ " W. "	"	John McGlin	"	"	"
3 " S. W. "	"	A. Cloud	"	"	"
3 " S. "	"	J. H. Thomas.	"	"	"
New Point	Decatur	W. W. Hollensbe	"	"	"
5 ms S. W. Greensb'gh	"	Greensburgh Limestone Co.	"	"	"
St. Paul.	"	W. W. Lowe	"	"	"
"	"	J. L. Scanlan	"	"	"
2 miles W. St. Paul	Shelby.	G. W. McNeely	"	"	"
Ellettsville	Monroe	John Matthews & Sons.	"	Bit. Limsetone.	Gray and drab
"	"	Perry Brothers	"	" "	" " "
Stinesville	"	W. H. McHenry	"	" "	Gray
"	"	McHenry & Brother	"	" "	"
"	"	Davis & Cassner	"	" "	"
Spencer.	Owen	B. Schweitzer	"	Limestone	Drab
N. E. Spencer.	"	Simpson & Archer	"	Bit. Limestone.	Gray
" "	"	E. R. Bladen	"	" "	"
" "	"	Howard & Denig	"	" "	"
5 miles W. Bedford.	Lawrence	N. C. Hinsdale & Co	"	Limestone	"
4½ " W. "	"	Voris, Rodgers & Co	"	"	"
1½ " E. "	"	Chicago Bed. Stone Co	"	"	"
" E. "	"	Fillion & Smith	"	"	"
Lawrenceport	"	A. F. Berry.	"	"	"
Fort Ritner.	Jackson	E. B. Dixon.	"	Bit. Limestone.	"
3½ ms N. N'th Vernon	Jennings	Hicks & Holmes	"	Limestone	"
North Vernon	"	P. Conklin & Co	"	"	Drab
3 ms S. North Vernon	"	H. C. Herrman	"	"	"
Oakalla	"	Hicks & Holmes	"	Mag. Limestone	"
Osgood	Ripley	Peter Wagner	"	" "	
"	"	Ashman & Glasgow	"	" "	
Salem	Washington	Emanuel Zink	"	Limestone	Gray
3 ms W. New Albany.	Floyd	Christian Haller	"	"	"
3 ms W. " "	"	N. Bittinger	"	"	"

SAND STONE.

Williamsport	Warren	B. F. Gregory estate	Sandst'e		Gray
Attica.	"	S. Bernhardt	"		Gray, blu gray.
French Lick	Orange.	W. F. Osborne	"		Gray
" "	"	T. N. Braxton	"		"
3½ ms E. Cannelton	Perry	A. Hallabach	"		Light brown

of Stone Quarried in the State of Indiana.

STRUCTURE.			Geological Age of the Formation.	Year Quarry was Opened.	Cubic Yards of Space Excavated since Quarry was Opened.	Cubic Feet of Marketable Product during Census Year.	No. Grades as regards Quality, Obtained.
As Regards Texture.	As Regards Stratification.	As Regards Bedding.					
Compact, vesic	Even and parallel	Thin to medium	Upper Silurian	1876	4,000	. . . .	One
Finely vesicular	Massive	Even, medium thick.	" "	1867	21,800	. . . .	One
Semi Crystalline	Wavy and irregular	Even and thin	" "	1866	36,000	. . . .	One
" "	" " "	" " "	" "	1876	2,400	434,700	One
" "	" " "	" " "	" "	1878	1,300	. . . .	One
" "	" " "	" " "	" "	1873	3,040	. . . .	One
Vesicular	Irregular.	" medium thick	" "	1866	53,000	. . . .	One
"	"	Uneven and thin.	" "	1873	26,000	. . . .	One
Semi Crystalline	Massive	" medium thick.	" "	1872	20,000	. . . .	Two
Fine and compact	Even and massive	Even, " "	" "	1840	100,000	. . . .	One
" " "	" " "	" " "	" "	1840	200,000	325,750	One
" " "	" " "	" " "	" "	1876	8,000	. . . .	Three
(Conchoidal fract.)	Even and indistinct	" and thin	Devonian	1850	20,000	. . . .	Two
Semi Crystalline	Variable	" " "	Upper Silurian	1864	23,600	. . . .	One
" "	"	" " "	" "	1864	20,000	. . . .	One
Fine and compact	"	Even, thin to medium	" "	1867	20,000	207,250	One
Semi Crystalline	Irregular.	" " "	" "	1870	30,000	. . . .	One
" Crys., vesic'lar	"	" and thin	" "	1855	13,000	. . . .	Two
" " "	"	" " "	" "	1855	14,400	. . . .	Two
Vesicular	Variable	" " "	" "	1835	21,800	219,000	Two
Fine and compact	Even	" thin to medium	" "	1840	7,250	. . . .	One
" " "	"	" " "	" "	1840	7,250	. . . .	One
Semi Crystalline	Massive	" medium thick	Sub Carbonif's	1869	2,510	. . . .	Two
" "	"	" " "	" "	1860	64,520	. . . .	One
" "	"	" " "	" "	1870	25,800	. . . .	One
" "	"	" " "	" "	1858	1,020,000	3,212,500	One
" "	"	" " "	" "	1873	48,390	. . . .	Two
" "	"	" " "	" "	1876	18,150	. . . .	Two
" "	"	" and thick	" "	1865	22,000	. . . .	One
Vesicular	Wavy and massive.	" medium thick	Upper Silurian	1862	10,000	. . . .	One
"	" " "	" " "	" "	1879	4,000	. . . .	Two
Semi Crystalline	" " "	" " "	" "	1877	10,000	. . . .	Two
" "	" " "	" " "	" "	1876	43,000	233,750	One
" "	" " "	" " "	" "	1870	80,000	. . . .	Two
" "	" " "	" " "	" "	1850	14,117	. . . .	Three
" "	" " "	" " "	" "	1878	1,575	. . . .	Two
" "	Massive	" thin to medium	" "	1875	4,000	. . . .	Six
" "	"	" " "	" "	1850	242,000	. . . .	Three
" "	"	" medium thick	" "	1854	127,680	1,224,500	Three
" "	"	" " "	" "	1859	135,000	. . . .	Three
" "	"	" " "	" "	1859	20,000	. . . .	Three
Granular (Oolitic)	"	Even and thick	Sub Carbonif's	1862	87,102	. . . .	One
" "	"	" " "	" "	1866	110,975	. . . .	One
" "	"	" " "	" "	1878	11,284	. . . .	One
" "	"	" " "	" "	1879	240	. . . .	One
" "	"	" " "	" "	1875	12,500	1,232,840	One
{Fine, compact. {Conchoidal fract.	} "	" medium to thin	" "	1869	170,000	. . . .	One
Granular (Oolitic)	"	" and thick	" "	1870	2,000	. . . .	Two
" "	"	" " "	" "	1879	14,400	. . . .	Two
" "	"	" " "	" "	1878	7,500	. . . .	One
" "	"	" " "	" "	1879	193,560	. . . .	Two
" "		" " "	" "	1879	300,000	. . . .	One
" "		" " "	" "	1876	290,340	420,150	Two
" "		" " "	" "	1867	8,000	. . . .	Three
" "		" " "	" "	1879	22,582	. . . .	Two
"	Even and parallel	" " "	" "	1860	20,000	. . . .	Three
"	Massive	Medium and thick.	Devonian	1875	64,500	. . . .	Two
Semi Crystalline	Irregular.	" " "	" "	1873	1,210,000	. . . .	Eight
" "	"	" " "	" "	1850	193,800	387,500	Six
" "	Massive	" " "	Upper Silurian	1876	129,080	. . . .	One
" "	Wavy and massive.	" thin	" "	1871	35,900	. . . .	Three
" "	" " "	" "	" "	1874	35,900	. . . .	One
Granular (Oolitic)	Massive	" and thick	Sub Carbonif's	1861	80,650	204,175	One
"	"	Even " "	" "	1840	43,600	. . . .	Two
"	"	" " "	" "	1850	30,000	. . . .	Two
					5,619,495	8,102,115	
		SAND STONE.					
Coarse	Coarse and massive	Even and thick	Car. (Conglom)	1860	20,000	. . . .	One
"	" " "	" " "	" "	1873	60,000	. . . .	Two
Fine and medium.	Even, fine, coarse	" medium thick	Sub Carbonif's	1850	1,600	311,712	Two
" " "	" " "	" " "	" "	1830	16,130	. . . .	Two
Medium.	Irregular.	" one 30 ft. stratum	Carboniferous.	1871	10,000	. . . .	One
					5,727,225	8,413,827	

Table indicating the Capital, Labor and Appliances Devoted to the

Capital.	Total Value of Material Quarried during the Census Year.	COUNTY.	NAME OF CORPORATION, COMPANY OR INDIVIDUAL.	LOCATION OF THE QUARRY.	Method Employed for Draining the Quarries.
$23,860	$30,750	Adams	B. P. Rice	Decatur.	Pump
		Wells	Kapp & Gardner	Bluffton	"
		Wabash	Bridges & Scott	Wabash	Natural
			Hubbard & Smith	"	"
			Phillips & Hipskin	"	"
			William J. Ford.	"	"
			Moellering & Paul	"	"
			Lillie & Shoemaker	"	"
18,000	22,750	Cass	Lux & Lux	Logansport	"
			J. E. Barnes.	"	"
			August Gleitz	"	"
		Howard	J. V. Smith	3½ miles S. W. Kokomo	Pump
			George W. Defenbaugh	Kokomo	By trench
16,250	9,725	Grant	D. R. McKenney	Marion	"
			Silvester Fankboner	"	"
			John Murphy	"	Natural
		Blackford	William Twibell	Montpelier	Pump
29,500	10,100	Delaware	George W. Carter	Eaton.	"
			Bosman Brothers	"	"
			L. D. Koontz	Yorktown.	"
		Madison	William Crim	Anderson	Natural
			J. W. Sanberry	"	"
36,000	39,000	Putnam	Patrick Ash	Greencastle.	"
			William Steegs	2 miles S. W. Greencastle	"
			A. J. Crawford	2 " " "	"
			Vandalia Railroad Company	2 " " "	"
			Moss & Hillis	Okalla	"
			Torr & Brother	"	"
			James Lee.	Putnamville	"
15,850	30,800	Fayette	Wilson Ball	Longwood	"
			R. H. Moffitt.	"	"
		Franklin	H. Reese.	2¼ miles N. W. Laurel	"
			M. E. Secrest	2¼ " W. "	"
			John McGlin	2½ " W. "	"
			A. Cloud.	3 " S. W. "	"
			J. A. Thomas	3 " S. "	"
			W. W. Hollensbe	New Point	"
146,700	116,000	Decatur	Greensburgh Limestone Company	5 miles S. W. Greensburgh	Pump
			W. W. Lowe.	St. Paul	"
			J. L. Scanlan	"	"
		Shelby	G. W. McNeely	2 miles W. St. Paul.	Natural
85,500	124,100	Monroe	John Matthews & Sons	Ellettsville	"
			Perry Brothers	"	"
			W. H. McHenry.	Stinesville	"
			McHenry & Brother.	"	"
			Davis & Cassner.	"	"
		Owen	B. Schweitzer	Spencer.	"
			Simpson & Archer.	3½ miles N. E. Spencer	"
			E. R. Bladen	3½ " " "	"
			Howard & Denig	3½ " " "	"
122,500	126,050	Lawrence	N. C. Hinsdale & Co.	5 " W. Bedford	"
			Voris, Rodgers & Co.	4½ " W. "	"
			Chicago Bedford Stone Co	E. "	"
			Fillion & Smith.	E. "	"
			A. F. Berry	Lawrenceport	"
20,000	24,000	Jackson	E. B. Dixon	Fort Ritner.	"
		Jennings	Hicks & Holmes.	3½ miles N. North Vernon	"
			P. Conklin & Co.	North Vernon	"
			H. C. Herrman	3 miles S. North Vernon	"
			Hicks & Holmes.	Oakdale.	"
25,500	60,000	Ripley	Peter Wagner	Osgood	St'm p'mp
			Ashman & Glasgow	"	
		Washington	Emanuel Zink.	Salem.	Natural
		Floyd	Christian Haller	3 miles W. New Albany	"
			N. Bittinger	3 " W. "	"
$539,660	$593,375		SAND STONE.		
$73,900	$40,400	Warren	B. F. Gregory's estate.	Williamsport	Natural
			S. Bernhardt	Attica.	"
		Orange.	W. F. Osborne.	French Lick	"
			T. N. Braxton	" "	"
		Perry	A. Hallabach	3½ miles E. Cannelton.	"
$613,560	$633,775				

rrying of Stone in the State of Indiana, and the Value of the Product.

BER AND KINDS OF MACHINES EMPLOYED.			EXPLOSIVES.		Months Full Time.	Months Idle.	LABORERS EMPLOYED.				No. of Horses.	Wagons and Carts.
For rrying.	For Hoisting.	For Dressing.	Material Employed.	Value of used in the past Year.			Greatest No. the past 10	Greatest No. in Census Year.	Quarrying.	Stone Dress'g.		
.....	.....	.....	.....	...	3	9	8	8	3	..	3	..
.....	.....	.....	.....	...	6	6	22	22	15	..	16	..
.....	.....	.....	Powder	$32	9	3	30	30	7	..	14	1
.....	.....	.....	"	10	6	6	6	6	3	..	2	..
.....	.....	.....	"	2	7	5	5	5	4	..	2	..
.....	.....	.....	"	3	9½	2½	25	13	7	..	8	..
.....	1 derrick.	.....	"	16	8	4	8	6	5	..	4	2
.....	.....	.....	"	15	8	4	15	5	3	..	..	..
.....	.....	.....	"	30	7	5	30	30	8	..	30	..
.....	.....	.....	"	21	6	6	20	8	4	..	8	..
.....	1 derrick.	.....	"	16	7	5	25	8	3	..	10	2
.....	1 "	.....	"	30	9	3	23	18	9	..	7	3
.....	.....	.....	.....	...	8	4	12	9	5	..	8	2
.....	.....	.....	Powder	10	8	4	12	8	3	..	2	2
.....	.....	.....	"	8	8	4	5	5	3	..	2	1
.....	.....	.....	"	7	6	6	17	7	4	..	..	..
.....	.....	.....	.....	...	2	10	20	12	5	..	10	..
.....	.....	.....	Powder Dy'mite	25	6	6	12	6	4	..	1	..
.....	.....	.....	Powder	6	8	4	10	8	7	..	4	..
.....	.....	.....	.....	...	8	4	18	18	6	..	24	..
.....	.....	.....	Powder	8	6	6	12	12	4	2	4	3
.....	.....	.....	.....	...	8	4	14	14	3	2	12	..
.....	1 derrick.	.....	Powder	30	9	3	20	7	7	..	6	1
.....	2 "	.....	"	90	9	3	17	15	15	..	4	3
.....	.....	.....	"	75	12	..	13	8	5	..	2	..
.....	2 derricks	.....	"	50	12	..	47	47	47	..	..	..
.....	.....	.....	"	60	9	3	25	11	4	..	3	3
.....	.....	.....	"	75	9	3	25	25	7	..	4	2
.....	3 derricks	.....	"	10	12	..	20	5	5	..	6	2
.....	1 "	.....	"	3	6	6	25	4	2	1	12	2
.....	.....	.....	.....	...	6	6	4	5	3	1	2	1
.....	.....	.....	Powder	1	4	8	10	10	5	..	8	2
.....	.....	.....	"	25	8	4	60	50	25	10	40	12
.....	1 derrick.	.....	"	6	8	4	50	40	20	20	50	5
.....	.....	.....	"	5	8	4	35	14	7	..	12	1
.....	1 derrick.	.....	"	5	7	3	21	21	10	3	14	5
.....	2 derricks	.....	"	6	7	5	15	6	2	2	6	2
.....	6 "	.....	"	100	12	..	175	105	90	15	10	13
.....	6 "	.....	"	15	10	2	175	60	47	10	3	3
m'd drill	2 "	.....	"	100	12	..	75	50	30	..	15	12
.....	.....	.....	"	13	8	4	7	7	7	..	6	2
nneler .	10 derricks.	6 gang saws.	"	150	9	3	140	75	68	..	10	6
" .	4 "	4 " "	"	36	9	3	60	40	20	..	6	3
" .	1 "	.....	.....	...	9	3	24	24	23	..	6	..
.....	1 "	.....	Powder	1	9	3	8	8	8	..	6	1
nneler .	1 "	.....	"	1	9	3	15	6	6	..	6	2
.....	.....	.....	.....	...	9	3	70	40	15	..	2	1
.....	3 derricks	1 saw	Powder	6	8	4	26	26	10	..	1	1
.....	1 "	.....	"	75	10	2	10	10	7	..	4	..
nnelers.	4 "	1 saw	.....	...	8	4	125	125	63	..	4	3
" .	4 "	.....	.....	...	9	..	75	75	60	..	1	..
" .	4 "	.....	.....	...	12	..	85	50	35	..	..	..
" .	4 "	.....	.....	...	9	3	150	80	50	..	2	1
.....	1 "	.....	Powder	10	10	2	18	8	8	..	6	1
.....	2 "	.....	"	3	8	4	12	12	8	..	4	1
.....	2 "	.....	.....	...	9	3	33	25	5	8	13	4
.....	4 "	.....	Powder	150	8	4	100	50	40	10	..	4
.....	.....	.....	"	100	10	2	65	40	40	..	22	3
.....	.....	.....	"	40	8	4	45	15	14	1	6	5
.....	4 derricks	.....	.....	...	8	4	75	75	60	12	6	2
.....	3 "	.....	Powder	Small	8	4	25	25	10	15	8	3
.....	4 "	.....	"	"	9	3	50	50	20	20	4	5
.....	2 " 1 crane .	3 gang saws.	"	60	9	3	35	25	25	..	5	1
.....	.....	.....	"	100	7	5	2	2	2	..	3	1
.....	.....	.....	"	50	8	4	4	4	4	..	5	2
13	89 derricks, 1 crane	14		$1,690			2,420	1,638	1,054	132	504	137
.....	3 derricks	.....	Powder	Small	8	4	12	12	7	..	4	..
.....	4 "	.....	"	$450	9	3	74	48	20	..	14	7
.....	.....	.....	"	10	8	4	30	30	15	..	14	6
.....	.....	.....	.....	...	9	3	10	10	10	..	4	2
.....	10 derricks.	.....	Powder	150	12	..	50	50	15	10	5	1
13	106 derricks, 1 crane	14		$2,300			2,596	1,788	1,121	142	545	153

These tables are full and complete, and for the first time afford our citizens a knowledge of this important and growing industry of their own neighbors and people. For facility of study the following recapitulation of totals is given:

Totals from Tables representing the Quarry Industries in the State of Indiana.

Cubical contents of the space in yards excavated since the quarries were opened	5,727,225
Number of cubic feet of marketable product moved during the census year	8,413,827
Capital invested	$613,560
Total value of material quarried during the census year	633,775
Value of explosives used during the census year (powder and dynamite)	2,300
Machines employed for—	
Quarrying—Channelers and steam drills	13
Hoisting—Derricks and cranes	107
Dressing—Saw-mills	14
Dressing—Gangs, 3 per mill	42
Greatest number of hands employed at any one time during the past ten years	2,596
Greatest number of hands employed during the census year	1,788
Number employed in quarrying	1,121
Number employed in stone-dressing at quarries	142
Number of animals employed at any one time during the census year (horses)	545
Means of transportation belonging to quarries—	
Wagons and carts	153
Cars	46

OOLITIC LIMESTONE.

This stone occurs in quarry beds in the counties of Owen, Monroe, Lawrence, Washington, Harrison and Crawford, in massive strata from twenty to thirty or more feet in thickness, consequently very abundant. It was adopted, after long, careful investigation in competition with the most favored stone in the nation, as the handsomest, best material for the new State House. A similar conclusion was arrived at by authorities charged with important public structures in this and other States throughout the Union from the lakes to the Gulf of Mexico, and from the Mississippi to the Atlantic seaboard. This has given a great impetus within the past three years to the out-put of oolitic limestone.

Besides the new capitol of the State, oolitic limestone is the principal material in the $2,000,000 court house, post office, residences and churches in Indianapolis, and the best court houses in this and adjoining States. It is also in use for the Cotton Exchange, at New Orleans; the most exposed parts of the new city hall, and the water tables of Lincoln Park, at Chicago; many of the expensive structures of St. Louis, to include the Olympic Theater; and the Custom House at Louisville. Within the present month orders have been received for an outfit, amounting to one hundred and fifty car loads, for first-class structures in the cities of Philadelphia and New York.

The oolitic limestone averages over 96 per cent. carbonate of lime, a degree of purity rarely if ever surpassed, and scarcely equaled in the world.

The stone crops out with bold, perpendicular faces, which record the standpoints of streams through the long ages during which they have been engaged in hewing out of solid rock their deep valleys; even back of this the striæ and erosions of the glacial age are seen, dating back to the beginning of quarternary time, supposed by many to have been several hundred thousand years ago. This stone has withstood the elements and their disintegrating action during these long periods, and will fully answer the requirements for permanent structures. The strata are from ten to twenty feet thick, homogeneous and of similar appearance in horizontal or vertical section, the stone comes soft from the quarry, and is easily sawed; but, being tough under the chisel, it may be carved with facility and rapidity into any desired ornamental forms.

Cement should not be used in connection with this stone, in face work, but lime used instead.

This stone may be confidently recommended for the erection of extensive permanent structures.

An influential public journal of this State has the following fitting remarks:

"To conceive fairly what a good stone is, you must keep in mind the conditions under which it is to rest and do service. In this climate it will have to bear, in the direct rays of a July sun, a heat of 120° on the outside, while inside it may not be more than 70°. This difference of expansion makes a tremendous strain on the structure of the stone. In winter it may have to bear an exterior temperature of 20° below zero, and an interior heat of 70° above, or 90° of difference, which is simply a gigantic effort of nature to break the stone, like the grip of a powerful man straining a stick across his knee. It must give to one side and another under the enormous force applied on that side and reduced on the other. It is no wonder that great masses of apparently compact, homogeneous rock open in cracks, split off in layers when set on edge, burst into pieces sometimes when moisture soaks into undetected crevices and freezes with a spreading force that puts to shame the power of a steam engine or a hydraulic press. The damaging power of climate on building material is well illustrated in the case of obelisks of Paris, London and New York. They had all stood for 3,000 years in the rainless, equable climate of the Nile, with as sharp an outline of hieroglyphics, the corners as perfectly cut, the marks of the chisel as plain as when they were cut in the quarries of Syene, by Rameses. But that on the Place of the Guillotine, in Paris, has decayed till the government has been forced to save the inscriptions for historical use by making plaster fac-similes, while there is completeness enough left to assure accuracy. That on the Thames embankment, but a few years away from its native air, is breaking on the sharp corners and minute lines. So is that in New York, though it seems but a month ago—and it is but a few months really—since Lieut. Gorringe landed it. A recent publication says:

"Once in position, it was forgotten, until now some investigating visitor has made the alarming discovery that it is wearing out. Many of the inscriptions are no longer clear, and the corners are becoming rounded. The cause of this is the climate, the obelisk having been accustomed to a semi-tropical region and perpetual heat."

The dilapidation produced by freezing and thawing—the most rapid disintegrating agency in nature—the changes from dryness to incessant moisture, from excessive heat to cold, the differences of temperature at the same moment between opposite sides of the same block, the tendency of lamination to split off, of unequal densities to force apart, are all grave obstructions of the service that building stone can do in this climate that would be very slight obstructions in more equable climates. But we have stone that will bear and resist them all, and the State Geologist very fairly claims that it is the best stone in the United States. It is what the new State House is made of.

Table showing the production and the places where consumed, of the Oolitic lime stone taken from the Bedford, Bloomington, Stinesville and Ellettsville quarries for the years 1877 to 1881 inclusive:

LOCALITY OF THE QUARRIES.	Car Loads, 1877.	Car Loads, 1878.	Car Loads, 1879.	Car Loads, 1880.	Car Loads, 1881.	Total Car Loads.
Bedford, Lawrence County	1,510	1,940	2,100	2,400	2,900	10,850
Bloomington, Monroe County	....	10	20	25	83	138
Stinesville, Monroe County	145	205	153	123	285	911
Ellettsville, Monroe County	412	400	415	600	1,087	2,914
Totals	2,067	2,555	2,688	3,148	4,355	14,813

Cubic feet per car load, 165; one cubic foot weighs 146 pounds.

The following table shows the places to which the Bedford stone has been shipped for the years 1877 to 1881 inclusive:

POINTS TO WHICH THE BEDFORD STONE HAS BEEN SHIPPED.	Car Loads, 1877.	Car Loads, 1878.	Car Loads, 1879.	Car Loads, 1880.	Car Loads, 1881.	Total Car Loads.
Indianapolis, Indiana	287	369	399	456	551	2,062
Other points in Indiana	91	116	126	144	174	651
Illinois	830	1,067	1,155	1,320	1,595	5,967
Kentucky	166	213	231	264	319	1,193
Other places outside of Indiana	136	175	109	216	261	977
Total shipments	1,510	1,940	2,100	2,400	2,900	10,850

The other quarries have shipped about the same proportion of their product to the above points.

The shipment of eighty-three car loads from Bloomington indicate the development of a new and important use of oolitic limestone. Messrs. Dunn & Dunn, from their quarries, half a mile east of the railway station, obtain buff and blue stone in strata, respectively six and seven feet thick, of superior quality for ordinary building purposes. Careful tests show that it will receive and maintain for interior decorations a fine polish. With demand for the full amount of their present capacity, they have shipped the entire output of their works to Sherman & Fowler, Chicago, and the establishment at Joliet, Illinois, where it is sawed in thin plates or "boards," planed, matched and polished. The product meets a vigorous demand, fully meeting the call of tasteful decorators for modest neutral tints; and is used for wainscoting, mantels, pilasters, and other interior ornaments, as well as table tops, etc. The demand is newly developed and constantly increasing, and will establish this a factor in architectural materials. The following analysis is by B. F. Adams, Jr., made at the laboratory of the State University:

ANALYSIS OF OOLITIC LIMESTONE—BUFF AND BLUE.

(From Dunn & Dunn's Quarry.)

White Stone.

Specific gravity	2.716	
Gangue (Residue of HCl)	1.1527	per cent.
Lime (Ca O)	53.5499	per cent.
Carbonic acid Anhydride (Co 2)	43.3218	per cent.
Magnesia (MgO)	.4238	per cent.
Iron Oxide (Fe2 O3)	.2328	per cent.
Alumina (Al2 O3)	.0640	per cent.
Manganese Oxide (Mn O2)	.0300	per cent.
Phosphoric acid Anhydride (P2 O5)	.0455	per cent.
Silicic acid Anhydride (Si O2)	.0387	per cent.
Water (H2 O)	.5873	per cent.
Total	99.4465	per cent.

Blue Stone.

Specific gravity	2.732	
Gangue (Residue of HCl)	1.5571	per cent.
Lime (Ca O)	53.5095	per cent.
Carbonic acid anhydride (Co 2)	43.0958	per cent.
Magnesia (Mg O)	.4457	per cent.
Iron Oxide (Fe2 O3)	.0908	per cent.
Alumina (Al2 O3)	.0886	per cent.
Manganese Oxide (Mn O2)	.0542	per cent.

Blue Stone—Continued.

Phosphoric Acid Anhydride (P_2O_5)............	.0594 per cent.
Silicic Acid Anhydride (SiO_2).....................	.0476 per cent.
Water (H_2O)..	.4199 per cent.
Total..	99.3686 per cent.

Prof. VanNuys, chemist, of the Indiana State University, remarks "the buff stone contains more iron than the blue," which is produced by a filtration of water, carrying with it ferric oxide, and also by action of the oxygen of the air changing perrous carbonate to ferric oxide, as the buff is always found more exposed to the air."

The Survey is under obligations to Thomas H. Johnson, M. A., C. E., for the following discussion of the building materials of our country, and "*Experiments upon the Transverse Strength and Elasticity of Building Stone.*" It is believed that this latter quality has not sufficiently engaged the attention of engineers and builders, nor has the subject been before investigated with such thoughtful care. Hence, these labored results, obtained by exact mechanical appliances, well adjusted and observed will prove a discovery of great value, and support the high estimate herein claimed for the Oolitic stone.

Mr. Johnson's great experience in the construction and determination of railways, bridges and other structures requiring strength and endurance as elements, give weight and power to his conclusions.

EXPERIMENTS

UPON THE

Transverse Strength and Elasticity of Building Stones.

By THOS. H. JOHNSON, C. E. M. A.

When the Board of State House Commissioners for the State of Indiana assumed the duties of their office, one of their earliest acts was to investigate the relative merits of the different building stones that might be available for the new State House. In the course of these investigations they procured samples of many building stones, both from quarries in the State of Indiana and in other States. These samples were of two forms, cubes two inches each way and bars one inch square and fifteen inches long. Specimens of the two-inch cubes from each quarry were sent to Maj. Gen. Q. A. Gilmore to be tested for resistance to crushing, and his report upon the same was published by the Board of State House Commissioners in their "*Report No.* 6," January, 1879. The one-inch square bars were placed in the "Stone Room," in which the Board of Commissioners have accumulated a fine cabinet of samples of various building materials. Through the kindness of the Board the writer was furnished with samples of these one-inch bars, so far as there were duplicates in their collection.

At the time these tests were made the samples were about one year old, and were therefore thoroughly seasoned. They were tested under transverse strain and the deflection under each application of the load carefully measured. From each deflection so measured, and the load producing it, the Modulus of Elasticity was calculated, and the Modulus of Rupture from the load under which the specimen broke.

The term "Modulus of Elasticity" is used by writers on strength of material to designate the *unit* or standard of measure of the elasticity of a material, and is an arbitrary and hypothetical quantity. All materials, however solid and rigid apparently, will stretch under tension, and shorten under compression, to an extent which may be measured if appliances of sufficient delicacy be used. Having found the rate at which any material will stretch under a given pull, we may calculate the force that would be necessary to stretch it to double its original length, supposing that rate of stretch could continue without breaking the material. The amount of that force, in pounds, would be the "Modulus of Elasticity." The same force that would stretch it to double its length would, if applied as a push or compression, shorten the piece to one half its length. Under transverse strains, the amount of bending depends on the amount of stretch along the bottom, and shortening along the top of the bar; and hence the measured deflections enable us to determine the modulus of elasticity of the material.

The modulus of rupture is the load that would break a beam one inch square, resting on supports one inch apart, the load being applied at the center.

The machine on which these tests were made was constructed from designs by the writer, and consists of an upright rectangular frame, with a double cross-bar a little above the center, on which are two knife-edge bearings on which to rest the test piece. These bearings are movable along the cross-bar so as to be readily adjustable to the length of the test piece. At the center of the test piece is a saddle carrying a stirrup on a knife edge, bearing over the center of the saddle. A dynamometer connects this stirrup to an eye in the top of a screw, which passes through a hand-wheel-nut attached to the lower cross-bar or sill of the frame. The dynamometer has a capacity of four hundred and fifty pounds, and is graduated to intervals of five pounds. By using a second pair of attachment rings for lighter strains, the dynamometer will read to single pounds up to fifty pounds. The accuracy of the readings of the dynamometer was verified before using by putting it in a Rehle testing machine and subjecting it to measured strains throughout the whole range of its scale. By this arrangement of saddle, dynamometer and screw, each test piece could be readily subjected to transverse strains of measured intensity.

To observe the deflections the following device was resorted to: A cord made of silk fibres, laid parallel and wrapped with fine metallic wire, was attached to the saddle and carried up through a hole in the cap of the frame, where it passed around a small pully on a horizontal spindle, upon one end of which was a small plate glass mirror. From this spindle the cord passed along the top of the frame, to a pully at the side, from which the end of the cord hung free, and carried a counterweight which was adjusted to balance the weight of the saddle, dynamometer and their attachments, thus relieving the test piece of all strains excepting those applied by the screw and registered on the scale. The counterweight also served to hold the cord taut, and insure a proper motion of the mirror, following the deflection of the test piece. The amount of the deflection is measured by reading, through the telescope of an ordinary transit or level, a graduated scale as seen in the mirror. This scale is set up at a distance of ten feet from the mirror, and admits of reading the deflections accurately to $\frac{1}{1000}$ of an inch.

In making the tests the piece to be tested was first accurately calipered for dimensions and placed on the bearings. The wheel was then turned until the index of the dynamometer began to move, showing that the slack was taken up and that the test piece began to feel the strain. The whole was then slowly backed off until the index just touched zero. In this position the mirror was then adjusted to show the zero of the deflection scale on the cross-wire of the telescope. Strains were then applied, beginning generally with ten pounds, and increasing by ten pounds intervals until rupture occurred, the deflection at each increase of strain being observed by an assistant at the telescope.

The results are appended both in tabular form and in diagram.

As the pieces differed in their sectional dimensions, it was necessary for more ready comparison, especially in the diagram, to correct the recorded deflections, so as to get the deflections due to standard dimensions of one inch square. This was done in accordance with the established principle that the deflection is inversely proportional to the *breadth* and to the *cube of the depth.* These corrected deflections only were used in constructing the diagram, and are given in the table in the several columns headed "*corr.*"

The modulus of rupture was calculated from the formula

$$R=\frac{3\,P.\,l.}{2\,b.\,d.^2}$$

in which R is the modulus of rupture, P the load producing rupture, l length, b the breadth and d the depth of the test piece, all in inches. In this equation the weight of the test piece is neglected; but the error arising from this is very small, and does not materially affect the results.

The modulus of elasticity was calculated from the equation

$$E=\frac{P.\,l^3}{4\,\triangle.\,b.\,d^3}$$

in which E is the modulus of elasticity, $\triangle$ the deflection caused by a load P, and the remaining factors the same as before.

The diagram sheet shows three groups of lines having their origins of co-ordinates respectively at A, B and C. The group A embraces all experiments on oolitic limestone, in which the quarry beds were horizontal, and the mode of preparing the sample known. Group B embraces all other tests except sandstones, in which the loads were so small and the deflections so great as to require a different scale of platting in order to keep them within the limits of the paper. They are shown in group C.

Group B contains four experiments on oolitic limestones, Nos. 3, 18, 19 and 33. Nos. 3 and 33 were sawed vertically from the quarry ledge, making the beds at right angles to the axis of the bar, like a strip sawed off the end of a board. With Nos. 18 and 19 the mode of working was unknown.

RESULTS.

A very interesting result of this series of experiments is the apparent relation indicated between the *resonance* of the samples, and their *strength* and *elasticity*. I use the word "indicated" because it is imposible to get an exact measure of the resonance, or to describe it except by the use of such relative adjectives as "dull," "clear," etc., which have no exact meanings, and are incapable of mathematical comparison.

Each bar before testing was held vertically, lightly clasped between the thumb and finger, near one end, and then struck with some hard object, usually another piece of the same stone. Some of them (notably No. 1) would give out a clear, ringing, musical note. Others, such as the sandstones, would respond with a dull thud, like dried clay or putty. Between these extremes there were various degrees of resonance which could only be described in the crude way mentioned.

Prof. John Collett, now State Geologist, while a member of the Board of State House Commissioners, had repeatedly pointed out the difference in the resonance of the different samples, and had urged its importance as an indication of their relative strength.

Sound waves occurring singly or at irregular intervals impress the senses as *noise*, while regularly recurring waves are recognized by the ear as *music*.

In order that a body shall possess the property of resonance two conditions are necessary. The particles composing the material must be so intimately united as to transmit from particle to particle the force of the blow; and there must be sufficient elastic recoil and re-recoil to produce sustained vibration. The same physical properties, therefore, which give a material strength and elasticity, should also give it resonance in a nearly proportional degree.

In the absence of a measure of the resonance, I may say that throughout this series of experiments, as nearly as the ear could estimate it, the resonance of each piece tested was proportional to the modulus of elasticity as found from the test.

Passing from this to the more exact results, we find the most striking feature to be the very marked difference between the sawed and tool-dressed specimens of oolitic limestone. Indeed when attention is called to the subject, it becomes apparent that such difference must occur.

It is well known that a stone, however large, may be broken by striking a sufficient number of blows with a hammer, along the line where it is desired to break the stone. In this process the force of the blows is expended in gradually weakening the cohesion of the particles in a line following the direction of the blows. This weakening is increased by each successive blow, until finally rupture occurs.

If large stones may be thus broken, it is evident that the many blows, needed to dress a small sample by hand, must largely affect its internal condition. The blows, too, are uniformly distributed over all faces of the sample, so that all parts of the interior are equally affected. The small dimensions of test pieces (usually 2-inch cubes, for comparison, and in this series 1 inch bars), renders it certain that the disintegrating effect of the tool penetrates throughout the mass. It should not, therefore, be matter of surprise that the tool-dressed samples show lower results than the sawed samples.

It may be objected that the samples sawed and tool-dressed are from different quarries, and that the differences may be due to inherent differences in the stone, and not to the difference in the mode of working. But a glance at the diagrams will show that the two classes separate themselves into groups too distinctly marked to admit of such an explanation. If the difference between the groups fell within the range of difference between individual specimens in each group, this objection might have force. But such is not the case; the highest of the tool-worked does not reach the lowest of the sawed samples.

In order to show that the tool-dressing has in like manner affected the 2-inch cubes sent to Gen. Gilmore, the crushing strength as reported by him is given in the last column of the table.

It should be here stated that the cubes and bars sent from each quarry, were in each case, prepared alike, so that where my samples were sawed Gilmore's were sawed, and where mine were tool-dressed his were also tool-dressed, and his reported results have been classified on this assumption.

The average results of the two groups are presented in the following table, for more convenient comparison:

Average Results from Experiments on Sawed and Tool-Dressed Samples of Oolitic Limestone.

	MODULUS OF		
	RUPTURE.	COMPRESSION.	ELASTICITY.
Sawed	2,338	12,675	4,889,480
Tool-dressed	1,477	7,857	2,679,475
Ratio of tool-dressed to sawed	63%	62%	55%

The close agreement between these ratios is remarkable. Referring to the general table it will be seen that the average results for sawed samples is obtained from only four tests, and that one of these, No. 1, shows an exceptionally high elasticity. It is probable that if the number of samples had been greater, this exceptional case would have had less effect on the average modulus of elasticity, which would then have been less than here given. If we assume the average of the other three samples as more nearly representing the general average elasticity of that class of stone, then the ratio of the modulus of elasticity of the tool-dressed to the sawed samples would be 62¾ per cent. It would thus appear that the disintegrating effect of the tool is equally fatal to correct results in experiments on all modes of resistance.

These experiments show that owners of quarries who desire their stone to be properly set before the public should never allow tool-dressed samples to be submitted for testing purposes, and that the results of tests heretofore published have no value for purposes of comparison, where the mode of preparing the samples is unknown.

Referring again to the diagrams it will be noticed that the lines representing the sandstones and the tool-dressed granites approximate to the form of the parabola, while the sawed Oolitic limestones, together with the Niagara and Devonian group, are approximately straight lines. The tool-dressed Oolitic limestones show, in some instances, a tendency toward a straight line, and in others a tendency toward the parabolic form.

The straight line means that the elasticity is constant and unimpaired up to the instant of rupture. The parabola means that the elasticity is diminishing with each successive application of the load. In both cases the results are unique. With all other materials that have been made the subject of experiments, it is found that the line representing the test is approximately straight for the first portion of its length, and parabolic for the last portion, the change from the straight line to the parabola being usually well defined, and marked by a sharp cusp or point on the line. This point is called the "*limit of elasticity*," and it marks the load under which the elasticity of the specimen first becomes impaired. With the sawed limestones it would seem that the limit of elasticity is greater than the tenacity, and that the stone fails by tension along its lower surface before its elasticity has been impaired. With all those cases which show the parabolic form, the elasticity had been impaired by the tool-dressing, so that the limit had been passed before they were subjected to strain. The sandstones, however, were sawed, and the parabolic form developed by them was not the effect of tools, but shows a low degree of elasticity as inherent in the stone itself, and which renders them not well adapted for beams or lintels.

The Oolitic limestone, which forms the leading feature of the foregoing series of experiments, is so little known beyond the immediate neighborhood where it is quarried, that it may not be out of place to give here a fuller description of it and of its character as a building stone.

Geologically it belongs to the St. Louis group of the subcarboniferous period and has been formed from the crushed remains of the marine shells, corals, etc. These have been pulverized to the condition of fine sand; their soluble impurities washed away, and their insoluble residue reunited into solid rock by a deposit of carbonate of lime as a cementing material. Its structure is, therefore, that of a close grained, compact sandstone, while chemically it is a limestone of rare purity.

Like the sandstones, it works freely under the tool, while the homogeneity of its particles and binding material enables it to be worked to a clean, sharp arris. Like the sandstones, also, and unlike other limestones, its formation in the ledge is massive and solid; not stratified with clay partings. It has no well defined cleavage in either direction, and is of nearly equal strength whether on "edge" or on "bed." The formation is generally about forty feet in thickness, and presents a solid face, from which the quarryman may choose his dimensions unrestricted by any conditions save his ability to handle and transport the blocks. The Egyptian obelisk or the mighty stones of Baalbec could be readily surpassed in these quarries.

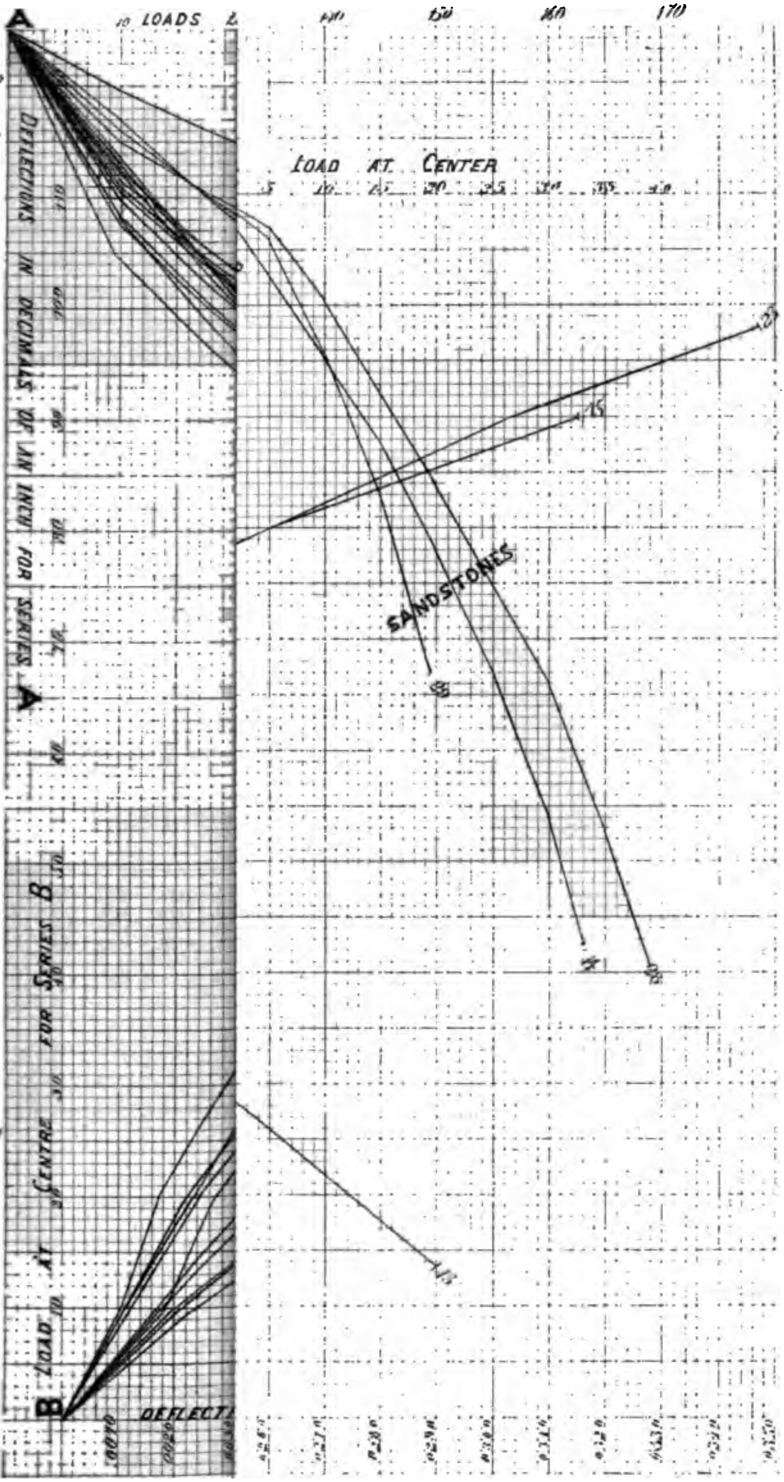
The Indiana Geological Report for 1878 gives analyses of samples from different quarries along the out-crop of the formation, from White river, in Owen county, to the Ohio river in Harrison county, showing a remarkable uniformity in its composition. All the samples show from 95 to 98 per cent. carbonate of lime, which is indestructible by ordinary atmospheric influences; while ferric oxide and alumina, to which most perishable stones owe their failure, occur here only from 0.34 to 1.00 per cent. This is a degree of purity rarely found.

In so far as durability can be inferred from chemical analysis, the oolitic limestone gives every assurance of permanence, which is further attested by the perpendicular and unworn aspect of all exposed faces along the out-crop and by its retention of tool-marks after forty years of exposure in buildings. It is only slightly absorbent of moisture; is perfectly free from saltpeter or other eflorescent salts; and its high degree of elasticity enables it to resist, without injury, the otherwise destructive effects of freezing the absorbed moisture, and of unequal expansion or contraction from sudden and unequal changes of temperature.

Its rich grey color, close and uniform texture, and facility of working, both by hand and by machinery, make it extremely valuable for architectural purposes, and its assured strength and durability make it especially desirable for all permanent engineering works. When it has become better known and appreciated abroad, it will form a prominent item in the commerce of the State. It is already beginning to find its way to eastern markets, and the recent use of it in Mr. Vanderbilt's new residence in New York city, will serve to show eastern architects its many excellencies.

INDIANA GEOL. REP. 1881.
PREPARED BY
THOS H. JOHNSON. C.E.

ONES



Resistance to Crushing—(Gillmore.)
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TABLE OF ALTITUDES.

Cincinnati, Indianapolis, St. Louis & Chicago Railway. Station Levels Between Indianapolis and Cincinnati.

Distance from Indianapolis. Miles.	STATIONS.	Above Ocean Elevation. Feet.
0	Union Depot, Indianapolis	721.20
	Shops, Indianapolis	747
	Pleasant Run, rail	769
7	Poplar Grove	861
9	Gallaudet	864
13	Acton	804
	Buck Creek, bed	770
	Sugar Creek, bed	762
16	London	787
20	Fairland	786
	Brandywine, bed	763
	Blue River, bed	759
27	Shelbyville	774
	Big Lewis Creek, bed	788
31	Prescott	801
	Conn's Creek	792
34	Waldron	831
37	St. Paul	864
	Flat Rock, bed	792
	Clifty Creek, bed	860
41	Adams	892
47	Greensburg	954
	Sand Creek, bed	939
50	McCoy's	1,039
53	Smith's Crossing	1,015
55	New Point	993
	Laughery Creek, bed	925
	Laughery Creek, rail	942
61	Batesville	980
64	Morris	994
68	Spades	1,025
69	Sunman's	1,027
73	Weisberg	941
79	Harman's	759
83	Guilford	520
86	Lawrenceburg	500
89	Valley Junction, Ohio	511
	White Water River, Ohio, bed	479

Cincinnati, Indianapolis, St. Louis & Chicago Railway—Continued.

Distance from Indianapolis. Miles.	STATIONS.	Above Ocean Elevation. Feet.
95	Cleves, Ohio	509
100	Delhi, Ohio	514
115	Cincinnati, Ohio—Plum Street Depot	513

Chicago & E. I. Railroad, from Terre Haute to Chicago.

Distance from Terre Haute. Miles.	STATIONS.	Above Ocean Elevation. Feet.
176	Lake Michigan, Chicago	585
176	Lake Michigan, high water 1848	588
161	Dalton	613
156	Thornton	631
154	Glenwood	638
151	Bloom	695
147	Crete	732
	Goodnow, (summit)	778
143	Goodnow	752
140	Beecher	732
133	Grant	706
128	Momence	635
	Palmer	644
117	St. Anne	667
113	Papineau	642
110	Martinton	637
	Pitwood	652
100	Watseka	645
96	Woodland	648
90	Milford	675
83	Wellington	709
	Hoopeston, (summit)	735
78	Hoopeston	727
72	Rossville	710
66	Alvin	673
63	Bismark	674
54	Danville Junction	618
	Vermillion River, ½ mile below Danville, low water.	511
	Danville, high water	535
	Highest point on T. H. & D. R. R	671
43	Perrysville	592
	Perrysville, low water Wabash River	489
36	Eugene	518
	Eugene, high water in Big Vermillion	?506
31	Newport	506
23	Hillsdale	500
15	Clinton	504
	Clinton, high water Wabash River	479

Chicago & E. I. Railroad, from Terre Haute to Chicago—Continued.

Distance from Terre Haute. Miles.	STATIONS.	Above Ocean Elevation. Feet.
15	Clinton, low water Wabash River	464
10	Atherton	533
	Otter Creek Junction	515
	Terre Haute, Chestnut street	504
	Terre Haute, low water Wabash River	451
0	Terre Haute, Union Depot	498

Indianapolis, Bloomington & Western Railway, from Indianapolis to Danville, Ill.

Distance from Indianapolis. Miles.	STATIONS.	Above Ocean Elevation. Feet.
0	Indianapolis, Union depot	721.20
2	Indianola	705
6	Carter's	752
10	Clermont	860
14	Brownsburg	893
18	Pittsboro'	953
20	Rainstown	978
22	Lizton	971
	Dividing ridge	984
28	Jamestown	968
	Raccoon Creek	903
33	New Ross	898
38	Mace	852
	Crawfordsville Junction	798
43	Crawfordsville depot	793
47	Troutman's	695
	Sugar Creek bridge	675
	Dividing ridge	825
54	Waynetown	763
59	Hillsboro'	728
	Coal Creek bridge	610
65	Veedersburg	622
	Dividing ridge	691
72	Covington'	537
	Wabash bridge	529
	Wabash river	491
74	Mound City, Sand Prairie	577
80	Beckwith, State Line	657
85	Danville Junction	622

Chicago & Indiana Block Coal Railway, from Attica to Yeddo.

Distance from Attica. Miles.	STATIONS.	Above Ocean Elevation. Feet.
	Attica, bottom of Wabash River	500
0	Attica, crossing T. W. & W. R. R	545
4	Shawnee Creek, bed	590
7	Straders	649
7½	N. fork of Coal Creek, bed	634
10	N. fork of Coal Creek, bed, second crossing	608
14	Veedersburg, I. B. & W. R. R. crossing	622
14¾	Coal Creek, bed	576
20¾	Yeddo	707
23	Harveysburg	699
25	Fountain & Parke Co.'s line, summit	712
27	Sylvania	694
30	Sugar Creek, bed of, Rockport Mills.	499

Cleveland, Columbus, Cincinnati & Indianapolis Railway, from Indianapolis to Galion.

Distance from Indianapolis. Miles.	STATIONS.	Above Ocean Elevation. Feet.
0	Indianapolis, Union Depot	721.20
4	Brightwood	804
9	Lawrence	884
14	Oakland	858
21	Fortville	870
28	Pendleton	859
37	Anderson crossing	907
41	Chesterfield	920
43	Daleville	923
48	Yorktown	927
53	Muncie	961
60	Selma	1018
67	Farmland	1053
75	Winchester	1101
	Harrisville	1114
85	Union, Indiana and Ohio State line	1121
94	Ansonia, Ohio	1013
97	Dawn, Ohio	1030
102	Versailles, Ohio	984
	Houston, Ohio	972
	Spafford, Ohio	105
120	Sidney, Ohio	98
126	Pemberton, Ohio	107
133	De Graff, Ohio	100
	Gretna, Ohio	109
142	Bellefontaine, Ohio	1229
	Summit, Ohio	1359

C. C. C. & I. Ry., from Indianapolis to Galion—Continued.

Distance from Indianapolis. Miles.	STATIONS.	Above Ocean Elevation. Feet.
158	Ridgeway, Ohio	1071
169	La Rue, Ohio	939
	Gurleys, Ohio	933
183	Marion, Ohio	991
191	Caledonia, Ohio	1009
203	Galion, Ohio	1181

Jeffersonville, Madison & Indianapolis Railroad.

Distance from Indianapolis Union depot.	POINT AT WHICH ELEVATIONS ARE TAKEN.	Above Ocean Elevation. Feet.
	Mitre sill of Louisville and Portland Canal—upper lock	390.00
110.00	Louisville depot, top of ties or base of rail	469.91
	Ohio River bridge, long span, base of rail	507.70
108.00	Jeffersonville, ninth street depot, base of rail	453.62
	Mill Run, bed of stream	452.30
102.85	"Five Mile Station," base of rail	477.42
	Silver Creek, bed of stream	441.60
	Silver Branch, bed of stream	462.00
99.56	Sellersburg, base of rail	490.00
99.30	Dividing watershed, original surface	497.00
98.20	Silver Creek, Muddy Fork, bed of stream	454.50
96.20	Hill, base of rail	507.62
	"Slate Cut," original surface	519.50
93.28	Memphis Station, bed of rail	500.50
	"Blue Lick" Creek, bed of stream	483.50
	Cane Run, bed of stream	492.00
89.43	Henryville, base of rail	515.00
	Wolf Run, base of rail	518.99
	Wolf Run, bed of stream	506.80
	(Up grade from this point at 26.93 feet per mile to)	
84.80	"Summit" Station, base of rail	630.17
	"Summit" Station, water divide, original surface	637.50
81.81	"Vienna Station," base of rail	577.89
	"Vienna Station," Pigeon Fork, bed of stream	558.00
79.31	Scottsburgh, base of rail	582.49
77.08	Marshfield, base of rail	555.00
	"Stucker's Fork," bed of stream	534.50
75.00	Austin, base of rail	561.00
74.50	Water divides, base of rail	575.75
	South Fork Muscatatack, bed of stream	527.00
71.70	Watershed, hill top, original surface	577.00
70.68	Crothersville Depot, base of rail	574.34
69.00	Retreat Station, base of rail	551.50
	Vernon Fork Muscatatack, bed of stream	528.00
67.01	Langdon's Station, base of rail	552.73
63.88	Chestnut Ridge Station, base of rail	570.58
	New Farmington, base of rail	594.00
	New Farmington, bed of stream	586.00

Jeffersonville, Madison & Indianapolis Railroad—Continued.

Distance from Indianapolis Union depot.	POINT AT WHICH ELEVATION WAS TAKEN.	Above Ocean Elevation. Feet.
59.00	Seymour Crossing, O. & M. R. R. track	619.99
56.92	Rockford Station, base of rail	593.86
	White River bridge, base of rail	596.52
	White River, bed of stream	568.00
	County Line, Jackson and Bartholomew, base of rail	601.50
51.75	Jonesville Station, base of rail	607.98
47.81	Waynesville Station, base of rail	618.00
45.70	Walesboro Station, base of rail	624.75
	White River bridge, base of rail	642.52
	White River, bed of stream	608.50
41.00	Columbus Depot, base of rail	642.52
	Flat Rock Creek, bed of stream	617.50
38.08	Lowell Station, base of rail	650.59
34.56	Taylorsville, base of rail	668.00
	County Line, Bartholomew and Johnson, base of rail	684.00
30.60	Edinburgh, base of rail	685.92
	Blue River, bed of stream	661.00
29.30	Water dividing ridge, original surface	707.00
	Sugar Creek, bed of stream	678.50
25.18	Amity, base of rail	705.00
23.20	Hill top, base of rail	746.00
	Hurricane Creek, base of rail	743.00
	Hurricane Creek, bed of stream	720.00
20.31	Franklin Depot, base of rail	743.50
	Crossing F. F. & M. R. R., base of rail	747.83
15.44	Whiteland, base of rail	812.50
11.40	Locust Grove, highest point on main line, base of rail	837.77
	Pleasant Run, bed of stream	809.50
10.68	Greenwood Station, base of rail	824.00
	County Line, Johnson and Marion, base of rail	806.00
7.00	Buck Creek bridge at Southport, base of rail	770.81
	Buck Creek, bed of stream	755.00
	Lick Creek bridge, base of rail	753.00
	Lick Creek, bed of stream	725.00
	Pleasant Run bridge, base of rail	729.00
	Pleasant Run, bed of stream	705.50
1.00	Crossing Belt R. R. track, base of rail	733.83
0.00	Indianapolis, Union depot, base of rail	721.20

Relative Elevations of Certain Points on the Cambridge Branch of the J., M. & I. R. R. Above Average Tide Level.

Distance from Columbus, Ind. Miles.	POINT AT WHICH ELEVATIONS ARE TAKEN.	Above Ocean. Elevation. Feet.
0.00	Columbus Depot, base of rail	642.52
6.38	Clifford Station, base of rail	676.50
9.15	St. Louis, base of rail	696.50

Cambridge Branch of the J., M. & I. R. R.—Continued.

Distance from Columbus, Ind. Miles.	POINT AT WHICH ELEVATION WAS TAKEN.	Above Ocean Elevation. Feet.
11.36	County line, Bartholomew and Shelby, base of rail	704.41
12.44	Flat Rock Station, base of rail	707.00
	Flat Rock River Bridge, base of rail	710.08
	Flat Rock River, bed of stream	686.50
15.12	Lewis Creek Station, base of rail	723.94
	Lewis Creek bridge, base of rail	726.46
	Lewis Creek, bed of stream	713.50
19.15	St. John's Station, base of rail	760.00
23.86	Shelbyville Crossing, C. I. St. L. & C. R. R., base of rail	779.99
29.93	Wray's Station, base of rail	875.30
	County line, Shelby and Rush, base of rail	905.00
32.86	Manilla Station, base of rail	907.00
	Mud Creek bridge, base of rail	922.96
	Mud Creek, bed of stream	908.50
35.11	Homer Station, base of rail	923.30
37.72	Goddard's Station, base of rail	952.00
39.79	Summit of Grade, base of rail	1,002.00
42.19	Rushville Station, base of rail	976.00
	Crossing C. H. & I. R. R., base of rail	983.68
	Flat Rock River bridge, base of rail	983.07
	Flat Rock River, bed of stream	966.50
	Turkey Creek bridge, base of rail	1,008.00
	Turkey Creek, bed of stream	995.00
48.31	Ging's Station, base of rail	1,013.00
49.68	McMillan's Station, base of rail	1,025.05
	Plum Creek bridge, base of rail	1,029.00
	Plum Creek, bed of stream	1,016.50
52.68	Falmouth, base of rail	1,061.00
55.12	Highest point on Cambridge branch, base of rail	1,084.03
57.23	Bentonville, base of rail	1,066.74
	Simmond's Creek, bed of stream	974.50
	Crossing Ft. Wayne, Muncie & Cincinnati R. R., base of rail	953.90
	Crossing White Water Valley R. R., base of rail	952.96
63.20	Cambridge City, junction P. C. & St. L. Ry., base of rail	952.59

Relative Elevations of Certain Points on the Madison Branch of the J., M. & I. R. R., Above Average Tide Level.

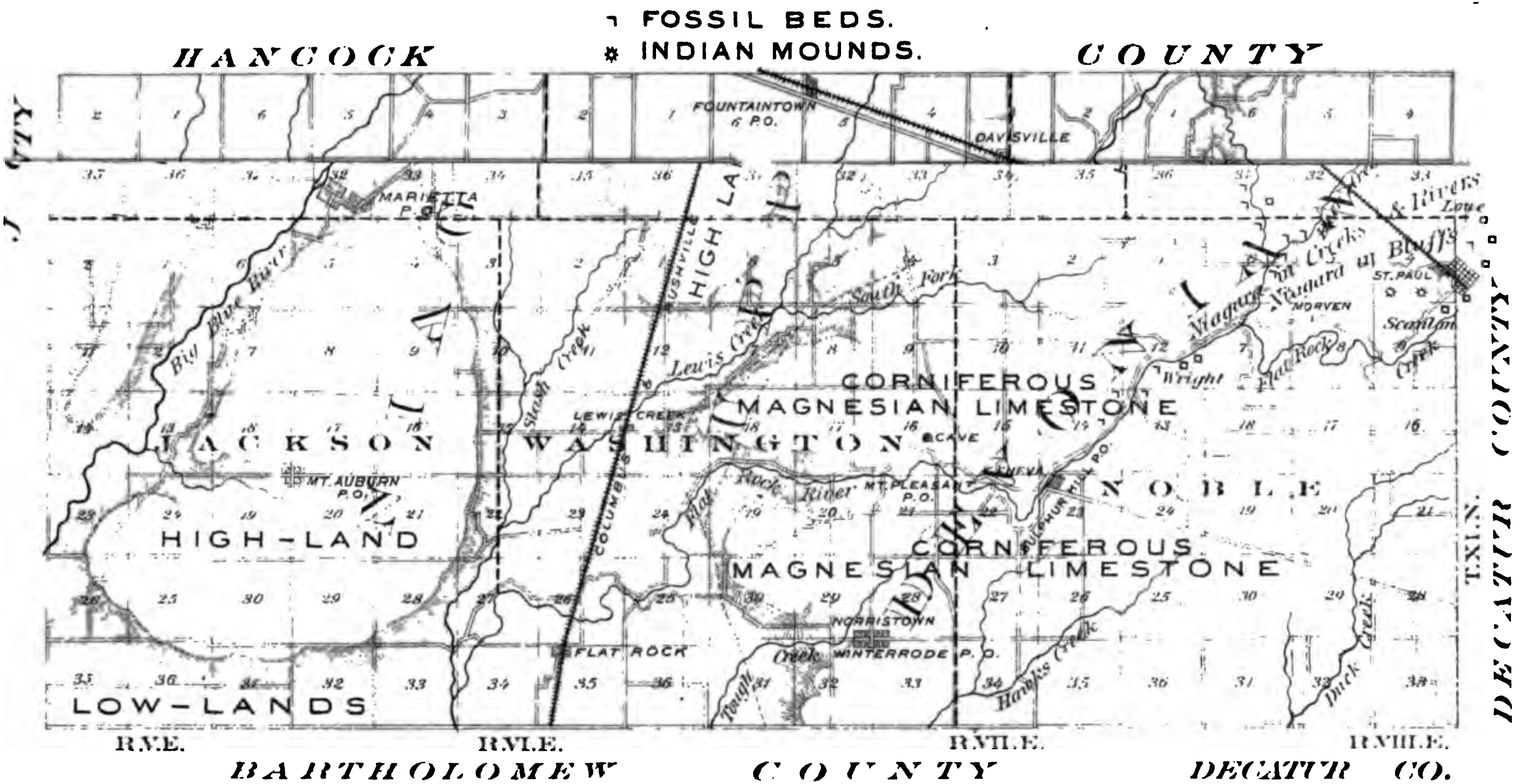
Miles from Columbus, Indiana.	POINT AT WHICH ELEVATIONS ARE TAKEN.	Feet Elevation.
0.00	Columbus depot, base of rail	642.52
0.74	Haw Creek bridge, base of rail	635.00
	Haw Creek, bed of stream	619.50
3.00	Clifty Creek bridge, base of rail	646.60
	Clifty Creek, bed of stream	613.00
4.62	Wigg's, base of rail	654.00

Madison Branch of J., M. & I. R. R.—Continued.

Miles from Columbus, Indiana.	POINT AT WHICH ELEVATION WAS TAKEN.	Feet—Elevation Above Ocean.
5.28	Bed of stream	616.00
6.40	Little Sand creek, bed of stream	619.00
7.06	Elizabethtown, base of rail	659.30
	County line, Bartholomew and Jennings, base of rail	687.00
9.25	Hill top near water tank, original surface	721.00
9.25	Summit of grade, base of rail	706.86
10.03	Stream crossing, base of rail	684.00
10.03	Stream crossing, bed of stream	645.50
10.40	Stream crossing, base of rail	674.00
10.40	Stream crossing, bed of stream	632.50
11.16	Summit of grade, base of rail	689.82
12.12	Tannersville or Rock creek, base of rail	680.50
	Sand Creek bridge, base of rail	673.52
	Sand Creek, bed of stream	613.00
14.11	Scipio, base of rail	691.50
16.23	Grade summit, base of rail	716.84
16.67	Top of hill, original surface	728.00
17.04	Queensville, base of rail	699.00
20.46	Summit of grade, base of rail	764.54
21.13	North Vernon, crossing O. & M. R. R., base of rail	738.57
22.74	Vernon depot, base of rail	699.00
	North Branch Vernon Fork Muscatatack, bed of stream	623.20
	Bridges, base of rail	680.56
	South Branch Vernon Fork Muscatatack, bed of stream	6[illegible]2.50
25.93	Butlers Station, base of rail	775.00
26.73	Summit of grade, base of rail	790.92
	Grahams Fork bridge, base of rail	776.20
	Grahams Fork, bed of stream	695.00
	Summit of grade, Jefferson County line, base of rail	813.16
31.67	Dupont, base of rail	795.00
32.47	Summit of grade, base of rail	813.81
	Big Creek bridge, base of rail	800.50
	Big Creek, bed of stream	736.00
34.85	Middle Fork Station, base of rail	824.00
	Middle Fork bridge, base of rail	820.04
	Middle Fork, bed of stream	759.00
38.58	Wirt's Station, base of rail	854.50
42.42	Highest point on Madison Branch, base of rail	892.15
42.88	N. Madison, top of incline plane, base of rail	887.56
44.90	Madison depot, terminus	462.51

The foregoing "*Table of Altitudes*" give a profile of the country along the respective railway lines in the counties surveyed and adjacent regions. The survey is indebted for this important information to the engineers of these roads, and I desire to return most hearty thanks for these valued favors.

On correlation of these lines, it is apparent that some discrepancy existed as to the assumed datum of surveyors, hence, part of these tables are useful only for levels of adjacent places.



Map of SHELBY COUNTY. Report of JOHN COLLETT, State Geologist, 1881.

GEOLOGY OF SHELBY COUNTY.

Shelby county was organized as a municipality, pursuant to an act of Legislature, in 1821, and contains an area of 408 square miles, or 261,120 acres. It is bounded on the north by Hancock, east by Rush and Decatur, south by Decatur and Bartholomew, and west by Johnson and Marion counties. Shelbyville, the county seat, is twenty-six miles southeast from Indianapolis. Sugar creek, Big and Little Blue rivers, and Flat Rock, are the principal water courses. These afford a large amount of water power, only a small part of which is properly utilized. Brooks and creeks ramify into all parts, affording stock-water and drainage to their respective districts.

The territory of which this county comprises a part was purchased from the Delaware Indians, by the government, at the treaty of St. Mary's, October 3, 1818, but by provisions of that treaty was occupied by the natives, and not offered for sale to the settlers until 1820.

In its present state of improvement and productiveness, it is hardly possible to imagine the situation at that time. The whole region was covered with a stately forest while the luxuriant soil filled every space with a tangled mass of bushes, vines and briers, almost impenetrable. The low lands and valleys, protected from evaporation by a dense shade, were wet, swampy, and in some places impassable marshes; without navigable streams or other avenues of commerce; without roads or even paths facilitating intercourse. To subdue this wilderness was the work of heroes and giants. The pioneer fathers bravely planned and planted for their descendants. Right worthily have their sons matured their schemes and made the wilderness give way to the bloom and realization of progressive civilization. Forests have been removed; the soil, mellowed by cultivation, reduced to productive tilth; marshes drained; railways and good gravel roads built; streams bridged, and well designed churches and school houses, visible from every hill top, indicate that the men of to-day are trustful guardians of the future, with indications of still higher progress.

The early settlers of Southern, and especially Southwestern Indiana, were from Kentucky. They brought with them the pluck and spirit of their old homes, but in the unequal contest with hordes of savages, the border line was often pierced and women and children exposed to savage, brutal butchery. At every signal of danger, at every call, or even without call, Kentuckians rushed to the post of danger, shielding with their breasts the defenceless homes of their Indiana brothers and sisters, sealing their devotion with their blood on every border battle-field. This county was named in honor of one of Kentucky's best and bravest sons, Governor Isaac Shelby.

SURFACE CONFIGURATION.

To the casual visitor the surface configuration is uniform and monotonous, except in the vicinity of Flat Rock river, in the southeastern parts, where hills and boldly escarped bluffs give variety to the view. As a rule the uplands slope gently to the rivers and creeks, presenting to the observer a great plain, nearly level, but with gentle undulations hardly sufficient to discharge the rainfall, without artificial drainage. The upland divides attain a pretty uniform elevation of 900 feet above the ocean. The valley streams are usually from 100 to 175 feet lower. In some regions soils are made up from the destruction of local rocks, hence lean and thin, or, in other parts, the stiff, cold clays of unmodified glacial drift prevail. Remote from great rivers or actual beds of water, one is astonished to find almost the whole surface of the county covered with alluvium, either ancient or modern. This explains at once the uniform depth and fertility of the soil, and asks what great floods of water and ice plowed out these valleys, contrary to the usual west-south direction of the drift, and afterwards covered the hill tops and glacial drift with the clay sands of the loess?

ALLUVIUM.

The forest mould and peaty soils are caused by the decay of leaves, grass and other vegetable remains. The alluvial loams of creeks and river bottoms, are due to causes now in action. Water, in swift motion, grinds rolling rocks and pebbles to sand and clay, a slow, but sure and mighty mill, and these, by floods, are spread upon the overflowed lands, blessing them with renewed fertility. These deposits are from two to ten, and, on the larger streams, twenty feet in thickness, and make a soil of unrivaled fertility, always productive and commanding full prices.

LOESS.

Going back, in order of time, was a period when a great lake of fresh water covered southwestern Indiana, and adjoining regions in Illinois, Kentucky, Missouri, etc. A sub-tropic or tropic climate prevailed. A southern vegetation was known to exist, with the Elephant, Megalonyx, Peccary, etc. This lacustral deposit in these parts exhibits a summit level of about 800 feet above the ocean; hence, shallow on the elevated plateaus and dotted with island hills, it deeply covered with its waters the valleys previously eroded. The inflowing streams gave rise to slow currents, so that the deposits are often finely and distinctly laminated. Few or no pebbles, only fine sands are found even upon its shores, for the temperature did not permit the transporting agency of ice. The loess deposit is seen on many of the highlands of the county, and is well exhibited in the wagon road cut at the hilltop near Mt. Auburn Long exposure to rainfall and other atmospheric conditions has removed most of the deposit from the slopes, and its material modified by fluviatile action largely forms the tenacious soil of the "flat woods," or enriched by coarse sand, the loams of the river bottoms.*

GLACIAL DRIFT.

The surface features of the county are largely due to the agencies of the great Ice age. The underlying rocks by paralellism of laminae and strata, indicate that when upheaved from their ocean birthplace the general surface was nearly level and now their general elevation would exhibit a line 1,000 to 1,100 feet above the ocean, drawn from the highest points in Rush, Decatur and Shelby westward to the knobs of Brown and Johnson counties; the intervening valleys being 300 to 500 feet deep. The hard-pan clays, gravel, and boulders indicate the transporting and erosive powers of that slow, solemn river of icy mystery, and its summer sluices of torrent water which has so wonderfully moulded the contour and blessed the soil of Indiana.

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*Bottoms are the meadow lands bordering on streams subjected to ancient or modern overflow.

These phenomena have heretofore been attributed wholly to the great northern ice flow, whose foot-marks are engraved with planished surfaces, furrows and striae, on many of the enduring sand and limestones of the State, northeast and northwest of this point; and whose crest is recorded on Bean Blossom ridge of Brown county, measuring an indefinite length north, and a thickness of at least 400 feet. With resistless power this great flow of nature cut down or overrode hills and divides, filling up previous valleys and water courses, and brought an immense burden of gray and white boulders and gravel from the granitic regions of Upper Canada, conglomerate pudding stones, traps and virgin copper from Lakes Huron and Superior, coal measure sandstones and fossils from Michigan, Silurian and Devonian rocks and identifying fossils from Canada, Michigan, Wisconsin, Illinois and Northern Indiana. The line of approach can be traced as easily as the Indian follows the footsteps of his enemy, and the boon granted by this grinding intermixture of crushed material from all the paleozoic strata is indicated by the wonderful and unrivaled fertility of our modified drift soils.

As a rule the Northern ice flow filled up ancient valleys and river beds, as was determined by test bores and shafts in Knox, Clay, Putnam, Vigo, Fountain and Tippecanoe counties, and as may be recognized in the sand and gravel pits near Waldron; pushing into such valleys, dividing hills and the masses of material beneath and at the foot of the glaciers and forming innumerable lakes, which dotted the entire surface of the State. At other times the ice flow followed North and South valleys, or depressions parallel with the outcrops of the geological formations, as the rocks were more or less easily eroded by it and the existing conditions.

But all these elements and agencies, set forth more fully in previous reports, can not account for the results exhibited in this and adjoining counties.

1. The trend of the streams and valleys do not coincide with the dip of the underlying rocks. On the other hand, with slight Southern deflections, they are parallel with the Western extension of the axis of Lake Erie, and parallel with the general trend of the great valleys or benches crossing the State from East to West. In former reports* on Knox, Owen, Putnam and Montgomery counties, isolated facts were given, which, massed as cumulative evidence, seem to comfirm a first glacial time, with flow from some Eastern point of dispersion.

2. The Northern ice flow brought white, gray and black granites, and a multitude of specimens, positively indicating the line of transit by Lakes Michigan and Superior. In Shelby county few such rocks are found, but instead, massive boulders, from small, to six, eight and ten feet in diameter, are constantly, abundantly seen in the Southern parts, of red felspathic granite, enough laminated to fix their gneissic or sedementary origin, closely resembling the red granites of Lower Canada and Vermont. With them, have been found in the State, a few fragments of crystalline magnetic iron ore, similar to the Andirondack ores, near Champlain, and many biscuit-shaped fragments of Medina sandstone, so common on the shores and ancient beaches of Lake Ontario, and more frequently Devonian corals, which are held typical of the Devonian age, in the bed of Lake Erie and Canada.

These facts, taken as a whole, seem to establish the extension of a first glacial drift from an extreme eastern point along the axis of Lake Erie across the State of Indiana, although the second north-south flow blotted or deeply hid nearly all the previous land marks. The writer submits these inferences, inviting observation of more facts, which may confirm or reject his theory here set forth.

An inspection of the map of the State discloses the fact that the valleys of the actual streams crossing the county from north-east to south-west, have their sources near the eastern boundary of the State, and a water-shed, or general valley extends from the dividing ridge in Rush county to a similar divide in Hendricks county, conducting a central water-shed distinct from those of the Wabash and Ohio, with bluffs at the extreme barriers 1,000 to 1,200 feet above the ocean, and with a valley depth of 300 to 500 feet. Over much, or all, the included space, at various depths are beds of gravel, sand and clays, showing that the whole included area has been subject to the denuding and modifying energy of currents of fresh water. This is especially true of Shelby county. Beds of gravel and sand are remarkably defined at Waldron and St. Paul, and in all the northwestern area; the irregularity of these pockets, of greater or less extent, often interrupted, very often partially removed, leaving mounds and knolls as the outliers at Waldron and St. Paul, indicates an inconstant stream, at one season with gentle current carrying only pebbles, sands and clays, but in the spring and summer, the season of melting ice, a mighty flood, with furious currents and sufficient volume to tear loose from the foot of the eastern glaciers great bergs and floating islands of ice, competent to bear the bowlders of red feldspathic granite, some of which contain 300 cubic feet, and would weigh from 40,000 to 60,000 pounds, and are common on denuded points in the south part of the county.

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*See Ind. Geol. Reports, 1875, pp. 305, 306, 364, 370, 424, 425. Rep. Statistics and Geol., 1880, pp. 400, 401.

COLLETT GLACIAL RIVER.

Crossing the western bounds of the county, this great stream of water and icebergs impinges against and is obstructed, by the hilly district of Johnson and Brown counties having an elevation of 400 to 500 feet above the valley, and is deflected south perpendicular to the dip or along the strike of the rocks to the southern boundary of the State at Jeffersonville. This valley is a wonderful exhibition of energy and forces which have ceased to exist. The volume may be estimated by the amount of the erosion, which exhibits a width of five to ten miles, and depth of 300 to 500 feet as measured by the wall-like bluffs of the adjoining high lands. The mighty ships which sailed upon this river sea were silvery bergs of ice, scattering bowlders along its shore line, or in its depths as discovered in deep wells in Scott and Clark counties, its broad eastern pathway indicated by lower silurian fossils, found in Ohio and Eastern

Indiana. Economically it furnishes an inclined plane, utilized as the roadway of the railroad from Indianapolis to Jeffersonville. In the course of ages the valley was tapped by newer lines of drainage along the dip of the rocks by the east branch of White river, and the old bed silted up at and near Seymour in Jackson county, depositing during this transition period of alternate eddy and current the vast hills and ridges of sand peculiar to that vicinage.

John L. Campbell, L. L. D., of the National Geodetic survey, to whom I am indebted for many valuable suggestions and observations, on examination found this depression to exactly correspond with the line he was directed to prepare for survey, [and greatly facilitating geodetic triangulation] has given it the name of "The Collett Glacial River," and kindly furnished the following letter of explanation:

WABASH COLLEGE, December 14, 1881.

JOHN COLLETT, PH. D., *State Geologist.*

DEAR SIR:—In the spring of 1878, in discussing the field for the United States Geodetic Survey in this State south of Indianapolis, you directed my attention to the section along the general line of the Jeffersonville, Madison and Indianapolis Railroad as specially remarkable for the terminal glacial action which gave the country the general character of an extended valley.

In my first geodetic report I took the liberty of naming this section "*Collett Glacial River,*" as a proper acknowledgment of your right of discovery.

An interesting question of State topography is the determination of the sources and borders of this extinct river.

The terminal line of the great glacier at the time of the formation of the river probably was not far south of Indianapolis. This glacier rested on a bed approximately 1,000 feet above the level of the sea.

The west bank of the river is well defined. The hills ten miles west of Edinburg have summits 900 feet above sea level. These hills may be taken as the starting point. Southward we find the summits west of Columbus are 950 feet above the ocean.

The summit of the sand hills in Jackson county are only fifty feet lower, while the tops of the knobs in Washington, Clark and Floyd counties rise again to 960 feet. At Spurgeon's Hill, on the line of the L., N. A. and C. railroad, the Aneroid barometer indicated 1,010 feet above sea level.

The general direction of the bank is south, with a slight bearing to the east in the southern part of the State.

The following table of hill summits, reduced approximately to sea levels, gives clearly the western bank of the river:

Woodruff's, township 11 north, range 4 east	890
Crooks', township 10 north, range 4 east	940

Taylor's, township 9 north, range 4 east	940
Conners', township 8 north, range 4 east	940
Baughman's, township 5 north, range 4 east	920
Finley's, township 2 north, range 6 east	960
Round Top, township 1 north, range 6 east	980
Top Knob, at six-mile switch L., N. A. and C. railroad	950

The outline of the eastern bank is not so well defined as the western. The limits may be approximately determined from the following altitudes:

Clarksburg, (hill north of,) township 14 north, range 5 east	870
Auburn Hill, township 11 north, range 6 east	880
Fairview, township 3 north, range 7 east	650
Guinea Knobs, lot 288, Clark's grant	750
Charlestown, lot 117, Clark's grant	600

The surface of the ground at Greensburg, on the Cincinnati, Indianapolis, Chicago and St. Louis railroad is 960. The summit level at Sunman, and westward, on the same road, is 1,015.

The flat table lands near North Madison, on the J., M. & I. R. R. is 880 feet.

The profile of the J., M. & I. R. R. shows the general character of the remarkable valley caused by this glacial river, and further modified by the present system of water courses:

Indianapolis	721
Greenwood	840
Franklin	740
Edinburg	683
Columbus	632
Seymour	600
Scottsburg	570
Henryville	500
Sellersburg	470
Jeffersonville depot	440

The elevations from Columbus to Seymour were taken by the Aneroid barometer; from Indianapolis to Columbus from the railway survey.

The difference of level between Vienna and Henryville, on the J., M. & I. R. R., is seventy feet, and the distance between the Knobs proper, on the west, and the Guinea Knobs, on the east, is only five miles. At this locality the glacial river must have been narrow and rapid. The great falls here doubtless contributed one of the grandest features of this most wonderful pre-historic river.*

This wide valley was cut in the otherwise level plane by the mighty river, wide and deep, whose life continued during the melting of the glacier, in the period intermediate between the geologic and the modern, but its tracings furnish an interesting feature in the topography of the State.

Very truly yours,

J. L. CAMPBELL.

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* We propose to name this locality Campbell's Falls.—*Collett.*

GENERAL SECTION.

1.	Recent alluvium	20 to 10 ft.
2.	Ancient alluvium	50 to 10 ft.
3.	Lacustral Loess	0 to 10 ft.
4.	Glacial drift	20 to 50 ft.
	Devonian.	
5.	Magnesian limestone, upper beds of Geneva limestone, *Corniferous*	38 ft.
6.	Rubble stone of Waldron and top of St. Paul quarries, *Corniferous?*	0 to 14 ft.
	Upper Silurian.	
7.	Blue shale, Waldron fossil bed, *Niagara*	7 ft.
8.	Blue limestone, *Niagara*	9 ft.
9.	Cherty limestone, top of St. Paul quarry, *Niagara*	8 ft.
10.	Laminated quarry strata at St. Pauls, *Niagara*	54 ft.
	Total	191 ft.

RECENT GEOLOGY.

The general section is an exhibit of all the strata and deposits of the county gathered from widely separated stations. The beds of recent or ancient alluvium have been generally referred to in the preliminary topographical description of the county. For specific information the survey is indebted to Mr. David Louden for a statement of facts of high interest to science, but even more valuable economically to those who desire pure water free from organic matter from the lower beds. Mr. Louden has bored more than a thousand wells in different parts of the county. In the valley of Lewis and Slash creeks, the wells sought water above the boulder clay, and along the bluffs or edges of these valleys and were from 12 to 18 feet deep, but along the center of the valley required a depth of 25 to 35 feet, or 20 to 25 feet below the present bed of the creek, showing that the ancient valley, 2 to 3 miles wide had a riverway eroded through the boulder clay to a depth of 30 to 70 feet as compared with adjoining highlands or bluffs.

Average Section of Wells on Lewis and Slash Creeks.

Black peaty soil	6 ft.
Yellow clay	2 ft.
Sand and fine pebbles	27 ft.
Total	35 ft.

A similar state of affairs exists in the beautiful and productive valley of Blue River, as is shown by the following:

Average Section of Blue River Valley.

Alluvial loam	2 to 6 ft.
Yellow clay	2 to 6 ft.
Sand and fine gravel	30 to 23 ft.
Total	35 ft.

A well made for Jacob Henry gives the following exhibit:

Section at Manilla.

Soil	3 ft.
Yellow loamy clay	7 ft.
Loamy sand	10 ft.
Boulder drift blue clay	47 ft.
Fine quicksand	3 ft.
Snow white sand	1 ft.
Gravel and sand	2 ft.
Total	73 ft.

Water was here as usual at the bottom of boulder clay, found in large supply, neither increasing in wet years nor decreasing at time of drouth. It rises to within one foot of the surface, and indicates a perennial fountain of pure water.

A well on the adjoining farms of Arbuckle and Mills, shows the following:

Section in Drift West of Manilla.

Soil	2 ft.
Clay	33 ft.
Quicksand	3 ft.
Blue clay	5 ft.

Section in Drift West of Manilla—Continued.

Clay and gravel	3 ft.
Boulder clay	17 ft.
Sand and gravel	3 ft.
Blue boulder clay	57 ft.
Total	123 ft.

All these bores indicate a probability of an abundant supply of pure water below the glacial or boulder clay.

At the residence of W. E. Teal, in the south-west part of the county seat, a bore gave the following results—commenced twelve feet above low water in Blue River:

Shelbyville Well.

Alluvial soil	8 ft.
Gravel	2 ft.
Fluvatile silt	1 ft.
Boulder clay	40 ft.
Sand and fine gravel	1 ft.
Limestone	1 ft.
Total	53 ft.

The following section shows the depth of the ancient river valley in one of the lowest points, the farm of Wm. Rouse, S. E. ¼ Sec. 3 T. 13, R. 5, near N. W. corner of Sugar Creek Township, a region of level, rich, agricultural farm land:

Section of Ancient Alluvium.

Black soil	25 ft.
Clay and sand	2 ft.
Gray clay and gravel	10 ft.
Quicksand	3 ft.
Gravel, fine, no bottom	5 ft.
Total	45 ft.

At Waldron, an elevated station, the ancient fluviatile action is well developed.

Section in Wells at Waldron.

Soil and loam	4 ft.
Yellow clay	6 ft.
Sand and gravel—fluviatile	14 ft.
Gray clay	1 ft.
Soft eddy clay—plants	27 ft.
Sand—snow white	1 ft.
Flat biscuits—Medina sandstone	3 ft.
Total	56 ft.

In the northeast corner of the county a well bored gives the following:

Section at Gwynnville.

Soil	3 ft.
Yellow clay. Loess?	6 ft.
Sand, Lacustral	10 ft.
Bowlder clay	35 to 47 ft.
White (and black magnetic) sand	1 ft.
Gravel and sand	3 ft.
Total	70 ft.

The ancient and recent alluvium of the river beds gives this exhibit, of alluvial deposits east of the railway in the southwestern parts:

Section in Alluvium at Flat Rock Station.

Loamy soil	3 ft.
Yellow clay	10 to 15 ft.
Sand	5 ft.
Gravel	1 ft.
Gray clay	1 ft.
Silt—fine clay and sand,—Lacustral, deep, still water deposit	19 ft.
Total	44 ft.

Other wells in the same vicinity find limestone at a depth of 60 to 70 feet, passing through similar deposits, and show an extreme erosive depth here.

The "Haw Patch," a great alluvial plain of wonderful fertility in the southwestern part of Shelby and the northwestern part of Bartholomew, has been pierced by wells to a depth of 60 to 70 feet. It presents a similar general section, indicating, first, the erosive action and confluence of an ancient affluent to the great glacial river before Flat Rock river was in existence; second, the gradual silting up of the channel by decrease of water or change of current, and, thence the deposit of underlying yellow clays and loess, during the subsequent lacustral period.

Section in Warner's Well.

(Two miles west of Flat Rock Station, section 32, township 11, range 6.)

Soil	3 ft.
Yellow clay—Loess?	2 ft.
Yellow sand—Loess?	30 to 20 ft.
Black muck	2 ft.
Snow white clay	½ ft.
Dark sand	4 ft.
Dark clay	½ ft.
Gravel washed clean	3 ft.
Total	35 ft.

Section in Scott's Well.

(Near Flat Rock Station, section 27, township 11, range 6, and within ten feet of river.)

Soil	3 ft.
Yellow clay	3 ft.
Gravel and sand, level of stream	10 ft.
Gravel and dust, absolutely dried	27 ft.
Gray clay	½ ft.
White sand	½ ft.
Gravel	3 ft.
Limestone	0 ft.
Total	47 ft.

These bores show an erosion to a depth of thirty-seven to forty feet below the present deepest channel of the river. The greatest thickness of the glacial or bowlder clays are shown in the following:

Section one mile west of Mt. Auburn.

(On farm of J. M. Collins, river bottom.)

Soil	4 ft.
Yellow clay	6 ft.
Sandy clay	10 ft.
Bowlder clay	80 ft.
White sand	1 ft.
Sand gravel	7 ft.
Limestone	0 ft.
Total	108 00

This shows the ancient river bed had a depth of fifty feet below low-water mark of Blue river.

HOT WELLS.

The construction of deep wells discovered the existence of thermal water quite unexpectedly. Although this fact has not attracted much attention, it is of economic importance. It is a well known fact that at the level of perpetual spring water a constant temperature of 52° F. is maintained in this latitude; thence downward, the temperature becomes higher with regular increments, and in this State the rate of increase has been found to be 1° F. for each space of 79 feet of depth. By this law we may, without estimating the cooling effects of the stony walls of the fissure and the inflow of surface water, safely conclude that a change of 28° F. indicates the source of supply at a depth of 2,212 feet.

The Shelbyville thermal well was put down in December, 1870, in the east part of the city, near Little Blue River bridge. At a depth of eighteen feet the water was found to be warm, and at the bottom, twenty-four feet from the surface, a constant temperature, winter and summer of 76° was maintained.

The Barlow thermal well is near Barlow's Mills, Sec. 3, T. 13, R. 6, nearly four miles west of Shelbyville. An old well, twenty-three feet deep, at the residence of Henry Barlow, had been used for household purposes, and was favorably known for furnishing cold water, 52° F. Suddenly the water became warm, and no longer desirable; the thermometer indicating 65° F. A pipe was driven in November, 1870, from the bottom, through fine sand and pebbles, resting in a bed of gravel, to a depth of sixteen feet, or thirty-nine feet from the surface. The water was found to have a temperature of 80° F., and during the next winter attained a maximum heat of 86°. These wells were excavated for potable water only, and being unfit for this use, were neglected and allowed to be filled up. If found permanent, these springs will invite the attention of those needing hot baths, and suggest that it would be cheaper (and surely more efficacious) to use the thermal waters of Shelby county, than the distant hot springs of Southern regions.

PALEOZOIC GEOLOGY.

The rocks of this county comprise a portion of the strata of the Devonian and Upper Silurian formations, and exhibit in outcrop a single group of each; the line of demarkation between the two formations will hereafter be seen to be the top of the Blue Shale fossil bed.

DEVONIAN AGE.

Corniferous Group.

The rocks of this age, although in some force, generally contain but few fossils, obscurely replaced with calc spar, as in the Magnesian limestone, No. 5 of general section, east of Flat Rock Station, at Geneva, and thence to the railway bridge at St. Paul. These rocks, although unfit for masonry, are of great economic importance, as will be later seen, furnishing a lime which invites the attention of manufacturers and architects.

At a few localities, as at Waldron and a short distance above Geneva, a rubble stone occurs, in convenient layers between the fossil beds and the magnesian limestone, of excellent quality and well suited for walls, hammered masonry, etc., and extensively used for fence posts. No fossils were seen, but it is probably of Devonian age as well, and together they represent the corniferous group here. These rocks probably cap all the hills in the southern parts, although hidden by clays and soils; it is probable that outliers of the black Marcellus shale of the Hamilton group may yet be discovered by deep bores or wells in the extreme western parts, though now deeply covered with drift soils and consequently unseen.

At a few localities in the southeastern corner of the county and the contiguous portions of Rush and Decatur counties, the identifying fossils given in the following lists were seen:

List of Fossils found in Shelby County.

DEVONIAN AGE.

CORNIFEROUS GROUP.

RADIATA.

Amplexus yandelli	Edwards & Haime.
Blothrophyllum decorticatum	Billings.
Cystiphyllum americanum	Edwards & Haime.
Cystiphyllum sulcatum	Billings.
Cystiphyllum vesiculosum	Goldfuss.
Clisiophyllum oneidænse	Billings;
Cyathophyllum corniculum	Rominger.
Cpathophyllum davidsoni	Rominger.
Cyathophyllum rugosum	Edwards & Haime.
Cyathophyllum juvenis	Rominger.
Cyathophyllum scyphus	Rominger.
Cladopora linneana	Rominger.
Diphyphyllum archiaci	Billings.
Diphyphyllum straminium	Billings.
Diphyphyllum simcoense	Billings.
Favosites emmonsi	Rominger.
Favosites hemisphericus	Yandell & Shumard.
Favosites canadensis	Rominger.
Favosites limitaris	Rominger.
Favosites clausus	Rominger.
Favosites epidermatus	Rominger.
Heliophyllum exiguum	Billings.
Stromatopora tuberculata	Nicholson.
Stromatopora nodulata	Nicholson.
Zaphrentis conigera	Rominger.
Zaphrentis gigantea	Rafinesque.
Zaphrentis ungula	Rominger.

BRACHIOPODA.

Ambocelia umbonata	Conrad.
Athyris vitata	Hall.

Atrypa reticularis	Linneus.
Chonetes yandelliana	Hall.
Productus spinulicostus	Hall.
Rhynchonlla tethys	Hall.
Spirifera angusta.	Hall.
Spirifera segmenta	Hall.
Spirifera varicosa	Hall.
Spirifera oweni	Hall.
Spirifera euruteines (*var fornacula*)	Hall.
Strophodonta demissa	Conrad.
Strophodonta arcuata	Hall.
Strophodonta macronata	Conrad.

PTEROPODA.

Tentaculites fissurella	Hall.

GASTEROPODA.

Bellorophon patulus	Hall.
Euomphalus cyclostomus	Hall.
Euomphalus decewi	Billings.
Lexonema nexile	Phillips.

CEPHALOPODA.

Cyrtoceras	*Sp.?*
Orthoceras	*Sp.?*

LAMELLIBRANCHIATA.

Conocardium trigonale	Hall.
Nucula lirata	Conrad.
Pterinea flabellum	Conrad.

CRUSTACEA.

Phacops bufo	Green.

UPPER SILURIAN FORMATION.

Niagara Group.

This formation is seen almost exclusively in the valleys of the extreme southern part of the county. A single outcrop is reported at low water in the channel of Blue river above Shelbyville. Limited in exposure, these rocks are written all over in symbols of the "life and times" of silurian seas.

A great ocean prevailed. The cool or cold water was of sufficient depth to relieve the bottom life from the pulverizing force of surface waves. Gentle currents flowed from north to south, as is shown by the shapes of the clay-stone concretions, without sufficient power to carry sand and coarse material. It was filled with marine life which in death built up calcareous bottoms from the crushed shells and other organic remains. At the close of this period an event transpired which shows that the occurrences of our day are but repetitions of the past. A great tidal wave swept across the quiet sea. Violent currents prostrated the plant like crinoids, or tore them from their rock-anchored roots, separating the stems in sections. Impure water came laden with death, and muddy shoal waters ended the growth of corals, burying all in a sepulchre of clay, in which they are preserved with wonderful perfection. To the geologist and student these graves give up their dead to tell in resurrection how their obedience to the laws of reconstruction, oscillation and compensation, modify and vary the surface of the earth. Life in this ocean was annihilated, or unfavorable conditions followed, as but few animal remains are seen in the superimposed rocks.

The Waldron fossil bed, No. 7 of section, is the grand paleontological bed of the district. It is found with well preserved fossils at St. Paul, near French's Mills, just below the railway track at the bridge, thence west at every exposure in the bluffs of Flat Rock, till it passes beneath low water within half a mile of Geneva, showing a dip W. S. W. of about forty feet to the mile. Outcrops still richer in fossils are found on Deer creek, and on Conn's creek from its mouth to a point a short distance southwest of Waldron. It is a ".Blue Shaly Soapstone," in regular beds, obscurely laminated, weathering to a light buff. Within its homely outcrop or breast are hidden the fossils which, to a large degree, illustrate this volume; have filled with beautiful specimens the cabinets of the world, and as developed have, like some old palimpsest, disclosed the still life of the past—a new Rosetta stone giving a key to its history and culminating death. Prof. James Hall, the distinguished geologist of New York, was one of the first to recognize the importance of these beds. He has expended large sums of money in their development, and more important, has brought to bear the results of his long experience, wise reasoning, and covered Conn's creek localities with a world-wide renown. The following is full though not complete list of fossils obtained to date, at Waldron and St. Paul, (the letters W. and St. P. indicating the localities,) in strata Nos. 7 to 10 of general section, and comprises those actually in the State Museum:

List of Fossils found in Shelby County, Ind.

UPPER SILURIAN.

NIAGARA GROUP.

PORIFERA.

Astylospongia præmorsa	Goldfuss—St. P. & W.
Astylospongia bursa	Hall.

POLYPI.

Favosites forbesi (*var occidentalis*)	Hall—St. P & W.
Favosites niagarensis	Hall—St. P.
Favosites favosus	Hall—St. P.
Favosites spongilla	Rominger—St. P.
Favosites pyriformis	Hall—St. P. & W.
Streptelasma spongiaxis	Rominger—St. P. & W.
Stromatopora concentrica	Goldfuss—St. P.
Strombodes pentagonus	Goldfuss—St. P.
Cyathophyllum radicula	Rominger—St. P.
Duncanella borealis	Hall—W.
Eridophyllum rugosum	Edwards & Haime—St. P.
Chetetes consimilis	Hall—W.
Trematopora infrequens	Hall—W.
Trematopora varia	Hall—W.
Inocaulis bella	Hall & Whitefield—W.

CRINOIDEA.

Cyathocrinus polyxo	Hall—W.
Cyathocrinus pusillus	Hall—W.
Saccocrinus christyi	Hall—W.
Eucalyptocrinus crassus	Hall—W.
Eucalyptocrinus cælatus	Hall—W.
Eucalyptocrinus ovatus	Troost—W.
Rhodocrinus melissa	Hall—W.

BRYOZOA.

Lichenalia concentrica	Hall—St. P & W.
Fenestella parvulipora	Hall—St. P & W.

BRACHIOPODA.

Pholidops ovalis	Hall—W.
Eichwaldia reticulata	Hall—St. P. & W.
Anastrophia verneuili	Hall—St. P. & W.
Retzia evax	Hall—St. P. & W.
Crania siluriana	Hall—W.
Crania setifera	Hall—W.

BRACHIOPODA—Continued.

Orthis elegantula	Dalman—St. P. & W.
Orthis hybrida	Sowerby—St. P. & W.
Rhynchonella acinus	Hall—St. P. & W.
Rhynchonella cuneata	Dalman—St. P. & W.
Rhynchonella neglecta	Hall—St. P. & W.
Rhynchonella whitii	Hall—St. P. & W.
Rhynchonella stricklandi	Sowerby—St. P. & W.
Rhynchonella indianensis	Hall—St. P. & W.
Meristina maria	Hall—St. P. & W.
Meristina nitida	Hall—St. P. & W.
Atrypa reticularis	Linneus—St. P & W.
Spirifera eudora	Hall—St. P. & W.
Spirifera crispa	Hall—St. P. & W.
Spirifera radiata	Sowerby—St. P. & W.
Strophomena rhomboidalis	Wahlenberg—St. P. & W.
Strophomena striata	Hall—St. P. & W.

PTEROPODA.

Conularia niagarensis	Hall—W.
Tentaculites niagarensis	Hall—St. P. & W.

GASTEROPODA.

Platyostoma niagarensis	Hall—St. P. & W.
Platyostoma plebium	Hall—St. P. & W.
Strophostylus cyclostomus	Hall—St. P. & W.

CEPHALOPODA.

Trochoceras waldronense	Hall—W.
Ormoceras . . *Sp. ?*	—St. P.
Gyroceras elrodi	White—St. P.
Orthoceras annulatum	Sowerby—St. P.
Orthoceras virgulatum	Hall—St. P.

LAMELLIBRANCHIATA.

Modiolopsis subalatus	Hall—W.
Amphicœlia leidyi	Hall—W.
Pterinea brisa	Hall—W.

ARTICULATA.

Cornulites proprius	Hall—W.

CRUSTACEA.

Cyphaspis christyi	Hall—W.
Calymene blumenbachi (*var niagarensis*)	Hall—W.
Dalmanites vigilans	Hall—W.
Dalmanites verrucosus	Hall—W.
Phacops limulurus	Hall—W.
Lichas boltoni (var *occidentalis*)	Hall—W.
Ceraurus (*Cheirurus*) *niagarensis*	Hall—W.
Homalonotus delphinocephalus	Hall—W.

The State Cabinet contains specimens of nearly every fossil here mentioned; hundreds of some species in many cases, and as crinoid roots, etc., individuals of every age, from the full-grown adult to the tiny speck, which developed with a lens, discovers the first delicate babyhood of the animal.

The "blue limestone" No. 8, is generally present, but not persistent, and is only in rare cases available for use.

The "cherty limestone" No. 9, is generally persistent, and is often an important strata, marking the floor of the fossil bed. Economically it is a drawback, and will so remain until the demand for permanent roads calls for its use.

The "laminated" quarry beds, No. 10 of section, are of high economicimportance. Geologically they are an argillaceous limestone, slightly magnesian, of a pale blue color, weathering to light gray, in regular beds varying from flags two to four or five inches thick, to strata of one or two feet, all evenly bedded and readily separated at the partings. The top and bottom of each strata is thus presented, ready dressed, and nearly ready for the mason. It is easily broken with drills and wedges to dimension stone, and furnishes, cheaply, good flags, rubble and dimension stone in unlimited quantity. A thousand car loads of this stone were shipped to Chicago in a single season. Large amounts of excellent lime are calcined from the St. Paul quarries, and the whole forms one of the important industries of the State. The fossils comprise Cephalopods, Orthoceras, Gomphoceras, Cyrtoceras, etc., with but few Brachiopods.

LOCAL DETAILS.

Shelbyville, the county seat, is a thrifty young city, situated on the east bank of the beautiful, clear flowing Blue river, and is surrounded by one of the richest agricultural regions of the State. Broad valleys, with strong alluvial soils, spread out an inviting mine of wealth, richer than "true fissures" in the land of speculation. Knolls and gentle headlands give modest variety to the landscape, and first class gravel roads radiate to all points of the compass.

The public buildings, court house, churches, school houses, etc., are tasty, but at the same time show careful thrift. Dwellings are often models of elegance, with careful regard for comfort and health, avoiding extravagance. The mills, distilleries and manufactories give employment to many, with fair returns to proprietors, and in success indicate energy, directed by thoughtful experience.

There are no outcrops of the underlying limestones near Shelbyville, and but a single one reported in the bed of Blue river. Bowlder drift, with striated gravel and rocks, build up the higher lands and plateaus near. The surface of the adjoining broad valleys are of fluviatile drift, of the present or ancient river, deeply covering the eroded bowlder drift beneath. The organic matter in these alluvial soils may explain the presence of "typhoid fevers" in some districts, and invites the use of water from deep wells or rainfall.

Cynthiana, one of the oldest settlements in the county, is situated on a ridge, which is well up to the summit level of the glacial drift. In fact, free gravel and sand containing black grains of magnetite, indicate it was probably the flood plain in the ice age, between the sluice torrents which poured down Blue and Flat Rock rivers, in their ancient volume. A landscape of quiet thrift and beauty is overlooked from the adjoining Leefers farm, along and across the valley of Conn's Creek, here ninety-five feet deep, and one or two miles wide. Manilla occupies about the same elevation, and thence to Gwinville the surface is a level, black soil, presenting the characteristics of a lake basin, sometimes still wet and peaty. It contains great elements of fertility, to be made available only by drainage. Timber is abundant and is marketed at stations on the railway. At Morristown, Blue River valley is forty to sixty feet in depth, and two to three miles in width, full of profitable farms. At Marion the earliest settlements were made, and the first courts were held under a tree, with logs for seats. The alluvial bottoms here produce full crops of corn, wheat and grass. An escarped bank of the river, seven miles northeast from Shelbyville, gives the following:

Section at Billman's Farm.

Soil	3 ft.
Yellow fluviatile clay	15 ft.
Glacial blue clay, with planished and striated bowlders and gravel	21 ft.
Total	39 ft.

About Fairland, and in fact all the northwestern part of the county, the surface is so level or gently rolling that it can only be characterized as a great farmland plain. The railway only indicates a difference of level at stations of ten to fifteen feet. Bores put down at several points find fluviatile sand gravel and alluvium to a depth of twenty to thirty feet. No further estimate of good returns and profitable farming is needed.

The southwestern and western parts of the county are characteristically valley bottoms, rich in strong, alluvial loams, and highly productive. The highlands are exceptional, limited in area and height.

Mt. McCrea, with its comrades, north of Marietta, are sharp, tumular hills, sometimes isolated by cross-flows from the northern or second glacial flow, they stand as silent monuments of past natural forces and offer interesting outlooks over broad fields of thrift.

The elevated region at Mt. Auburn invites the attention of fruit growers. Surrounded by low valleys to which the heavy cold air settles in times of sudden "cold snaps," these highlands are largely benefited by the mitigating and equalizing effects which are a constant result. It is a romantic scene. East the valleys of Lewis Creek and Flat Rock are displayed in level fruitfulness ten to fifteen miles; west the alluvial bottoms of Blue river, Sugar creek and White river extend to the terraced "Wall Bluff" of the great glacial river, in Johnson county, fifteen to twenty miles away in the blue distance. At Nibel's Mill, section 29, township 11, range 6, a mile south, the same view is enjoyed over an area forty by thirty-five miles, or 1,400 square miles. A deposit of loess sands in the road cut indicates by the red color the shore-line or shallow water of the lacustral basin, while false bedding with faces in that direction, indicate the widest and deepest water of the lake to have been west-south-west.

St. Paul, at the eastern line of the county, is noted for its extensive quarries and for the great amount of good stone and lime shipped. The level region heretofore prevailing is here varied by precipitous hills and bold outcrops which exhibit in different localities a complete series of the rocks seen in the county.

Section at Floyd's Mills.

(East part of St. Paul.)

Slope and gravel	55 ft.
Magnesian (Geneva) limestone—corniferous	2 ft.
Flinty blue limestone	5 ft.
Rubble stone	18 ft.
Waldron fossil bed, blue shale	7 ft.
Gray cherty limestone	14 ft.
To Mill Creek	....
Total	99 ft.

This bed contains many fossils. A list is given (ante) in this report.

The quarry of W. W. Lowe & Co., a short distance northeast of the village, is in Decatur county, but shipments are made from St. Paul. They employ during the summer months fifty to eighty men, have seven derricks and a full complement of drills and other tools. The opening shows a limestone face of 1,200 feet. They furnish dimension stone for foundations, piers, steps, lintels, sills, etc., and flags and curbs for sidewalks. The chief markets are at Indianapolis, Cincinnati, Terre Haute and Chicago, where it rivals the Joliet stone. The demand for flag and curb stone is extensive and the supply inexhaustible. The dimension stones are very generally used in Ohio and Indiana for jails.

Section in Lowe's Quarry.

Chert and slope—Niagara	2 ft.	00 in.
Rubble, 4 to 8 inch beds	12 ft.	00 in.
"Milk Trough" ledge	1 ft.	08 in.
Flag		04 in.
White dimension stone	1 ft.	00 in.
White dimension stone		09 in.
White dimension stone	2 ft.	00 in.
White dimension stone	1 ft.	00 in.
White dimension stone		11 in.
White dimension stone	1 ft.	02 in.
Flag		05 in.
Light gray dimension stone	1 ft.	06 in.
Light gray dimension stone	3 ft.	04 in.

Section in Lowe's Quarry—Continued.

Flag	07 in.
Dark blue limestone	1 ft. 08 in.
Blue laminated—splits to flags, eight feet below bed of river	1 ft. 06 in.
Total	29 ft. 10 in.

In the western or Shelby county part of the village of St. Paul, John L. Scanlan employs fifty hands, two compound derricks with a good equipment of tools, drills, etc., and two powerful steam pumps, which throw 1,000 gallons of water per minute. The product is dimension and cut stone for foundations, piers, building stone, especially for jails, paving flags and curb stones. The large demand shows the extensive use, and the high estimation placed upon this material by engineers, architects and the public. The rubble stone in the upper beds is largely used for calcining. The waste of the quarry is broken to regular "egg" by a Blake crusher, driven by a forty horse power engine with a capacity of preparing one hundred cubic yards a day, suitable for metaling pikes, ballasting railways or concrete foundation. This broken stone is sold in car load lots at fifty cents per cubic yard. The proprietor has also in operation two common kilns for calcining limestone, and one "perpetual burner," having a combined capacity of over five hundred bushels a day. The lime is "hot," of good quality for masonry, and extensively used at the Cincinnati gas works. We are indebted to P. McAuliff, superintendent, for specimens and information. The following exhibit was seen:

Section at Scanlan's Quarry.

(West St. Paul.)

Slope, stripping—Niagara	6 ft. 00 in.
Gray limestone in 4 to 10 inch strata, used for calcining, ballast and rubble foundations	30 ft. 00 in.
Stratified limestone, same use	8 ft. 00 in.
Gray flag and dimension stone in strata 4, 6, 8, 10 inches	5 ft. 00 in.
White limestone—may be split	1 ft. 04 in.
White limestone	1 ft. 02 in.

Section at Scanlan's Quarry—Continued.

Blue dimension stone	10 in.
Choice flags	04 in.
Blue dimension stone, to level 3 feet below surface of river	1 ft. 08 in.
Total	54 ft. 04 in.

The fossils found in the Lowe or Scanlan quarries are almost wholly Cephalopods, with rarely a Crinoid or Coral. A full list is given (ante) in this report.

The ancient valley of Flat Rock is two to three miles wide. Many mounds or hillocks of gravel and sand exist, showing the sorting process of flowing water, and we assume that the surface clay, measuring a vertical height of 100 to 125 feet has been carried away. Great red gneiss boulders of 10, 20, 30, 50, 94 cubic feet are seen upon the surface, attesting the transporting power of glaciers or floating ice. One bowlder, near Moscow, Rush county, is nine feet long, and nearly the same in cross dimension, including nearly 700 cubic feet.

Going down Flat Rock the "Waldron" fossil bed is seen a short distance southwest of town, thence, dipping faster than the fall in the river, each of the subordinate strata pass below the surface water, and near the mouth of Conn's Creek, the fossil bed approaches the same level and the valley widens to from a half to a mile or more. The "Blue Shale" fossil bed here is pyritiferous, and on exposure decomposes, becomes soft, and was borne away by the flowing water, undermining and breaking down overhanging rocks, which in turn were pulverized by the currents and removed. This explains the breadth of the valley. At Geneva, where this bed passes under the bed of the river, precipitous bluffs close in again.

A good fossil locality was visited, and the following taken:

Section at George Wright's.

(Section 12, township 11, range 7.)

Slope, clay drift	40 ft.
Laminated limestone, weathering buff, Devonian	12 ft.

Section at George Wright's—Continued.

Blue shale, fossil bed, Niagara	5 ft.
Argillaceous cherty limestone, in river	4 ft.
Total	61 ft.

Half a mile below a quarry is worked principally for stone fence posts, etc.

Section at Cuskader's Quarry.

(Section 13, township 11, range 7.)

Slope	25 ft.
Geneva magnesian limestone, partly covered, Devonian	12 ft.
Flags—fence posts	5 ft.
Buff limestone	4 ft.
Flaggy limestone	7 ft.
Blue shale, fossil bed, Upper Silurian, Niagara	4 ft.
Covered to river	3 ft.
Total	60 ft.

A similar outcrop occurs in the same section at the falls of Dudley creek, on the farm of Mary Wurtz. Nearly opposite, on the west bank of the river, the blue shale approaches the water surface, where it is rich in small fossils. The following exposure was seen:

Section at Mitchell's Cove.

(Section 14, township 11, range 7.)

Soil	2 ft.
Geneva magnesian limestone	10 ft.
Argillaceous limestone	5 ft.
Rubble limestone	9 ft.
Blue shale fossils to cherty limestone in river	6 ft.
Total	32 ft.

A small spring brook, flowing through a crevice, has worn away a circular grotto thirty by fifty feet in diameter, forming a romantic, cool, shady nook. The perpendicular walls are wreathed with twining vines and plumed with arrowy ferns.

At Geneva, half a mile below, the fossil bed has passed out of sight, and is nine feet below the water surface in the river.

Section at Geneva.

Slope and soil, buff magnesian limestone, for calcining, *Devonian*..........	28 ft.
Stratified rubble limestone, cap of fossiliferous Blue Shale, to same in river..........	4 ft.
Total..........	32 ft.

The Geneva limestone calcined, furnishes a pure, white lime of superior quality, which thoroughly slakes, works "cool" under the trowel, and sets without "popping" or "crick." These qualities give an extensive demand beyond the possibilities of wagon transportation, and invite railway competition. Equal to the Utica lime, near Louisville, it possesses, besides other good qualities; the feature that it is easily and economically quarried, and being porous, is calcined with a small per centage of fuel. The output of three common kilns supplies the vicinage and the few car loads hauled to the railway at Shelbyville.

A similar outcrop, giving a thickness of thirty-two feet of magnesian limestone, is seen at Nelson's Cave Mills, S.W. ¼ Sec. 16, T. 11, R. 7. Opposite the mill, an oval opening, six feet high by five feet wide, discharges the drainage from a considerable area of rainfall. Half a mile north of the mill, a doorway four feet high, leads to a cavern with several rooms, and a dome is reported to have a height of twenty-five feet, an evidence of the solving power of acidulous rain water acting upon limestone. The Geneva limestone, with all its good qualities, is the surface rock of the high lands about Wright's, Geneva, Mt. Pleasant, and especially accessible in the uneroded hillocks, near Norristown, where it has been used for stoning a turnpike, and thence westward toward Flat Rock Station, at Ensley's ford of Flat Rock, the upper bed of this limestone is seen, forming the solid floor of the river, a little over a mile west of the railway station.

CONN'S CREEK.

Waldron is a home-like station on the Cincinnati, Indianapolis, St. Louis & Chicago Railway. One of the highest points in the county on this railway, it has promise of a salubrious air. The surrounding farmers show thrift in their well appointed farms and residences. Much of the adjoining region has a soil made loamy by a generous admixture of sand, and sometimes underlaid with valuable beds of gravel, indicating the former course of rivers or glacial sluiceways. But still more has it gained a widespread reputation, by the discovery long ago of rich beds of fossils on Conn's creek. Described and illustrated by the patient zeal and broad knowledge of Prof. James Hall, State Geologist of New York, the "Waldron fossils" are known and recognized throughout the scientific world. Hotels and equipments are found at the village, and within a mile the first "Waldron beds" are to be seen. Several cabinets of fossils may be visited, of which that of Dr. Washburn is full of choice specimens. Mr. J. T. Duty is a successful collector.

Section on Conn's Creek.

(McNeely farm, N. E. ¼, Sec. 6, T. 11, R. 8.)

Slope—with Devonian bowlders		20 ft. 00 in.
Soil—stripping	15 to	5 ft. 00 in.
Rubble, laminated limestone, Devonian?	12 to	3 ft. 00 in.
Niagara "blue shale" weathering buff, with few fossils		2 ft. 02 in.
Blue shale, as above, filled with fossils		3 ft. 00 in.
Coral crag, bryozoans, etc, pyritiferous dark		06 in.
Dark shale, pyritiferous fossils, to flags in creek		04 in.
Total		34 ft. 00 in.

At other locations the underlying strata are seen as follows:

Section beneath Waldron Fossil Bed.

Flaggy limestone	14 ft.
Cherty limestone, top of St. Paul quarry	8 ft.
Total	22 ft.

At the Major's farm on the opposite side, or east bank of the creek, although nearly a mile distant, a section is given to show the uniformity of strata.

Section at Major's Wire Bridge.

(S. E. ¼, Sec. 6, T. 11, R. 7.)

Slope, fluviatile drift	25 ft.
Rubble limestone	8 ft.
Fossil bed	6 ft.
Stratified limestone, buff	14 ft.
Total	53 ft.

Without repeating sections it is thought best to give a list of outcrops with localities, so that visitors may at once reach those not before mentioned.

LIST OF OUTCROPS OF "WALDRON" FOSSIL BEDS.

Mill Creek, N. E. part of St. Paul.
Railway bridge, St. Paul.
Sullivan's—Bailey's Mill, St. Paul.
Carlisle's, Sec. 6, T. 11, R. 7.
Cuskaden's, Sec. 12, T. 11, R. 7.
Fairbank's, on Deer Creek, Sec. 6, T. 11, R. 7.

For list of fossils, see (ante) description of general section.

The physical phenomena of Shelby county represent ages of life, centuries of energy, cycles of time, writing with mightier hand than wields pen of lead or iron, events on the rocks forever. The romantic history it tells is of a deep, cold, quiet sea, and unseen life of mollusk and radiate; it records attending astronomic changes of climate and time, and leaves a thousand log-books of wondrous ships of chrystal silver, floating on a river-sea of icy water.

ARCHAEOLOGY.

The only earthworks by prehistoric man were seen adjoining the village of St. Paul. A mound thirty-two feet in diameter, and nearly six feet high, is built on the brow of the terrace bluff, overlooking the river in the valley and commanding a wide view toward "sunrise" between the rocky hills. When explored it contained human bones, which on exposure, quickly went to dust. They were covered with flags, supported by a stone wall, indicating a national vault or grave. Several smaller tumuli, possibly habitation mounds, were seen near by. Many interesting stone implements have been found scattered along the valley of Flat Rock river, evincing the taste as well as skill of the ancient inhabitants, and that if not their permanent home, this was at times a favorite hunting and visiting locality.

ECONOMIC GEOLOGY.

A good soil and productive agriculture is a sure basis of prosperity. The citizens of this county ought to be prosperous and happy. There is no waste land; all is susceptible of tillage or paying use. Nine-tenths of the area is nature's garden soil, black, deep and rich, producing good crops of corn, wheat and grass. No manure is used or required. Setting to grass or an occasional crop of clover will restore or indefinitely maintain the original fertility. Farms were noticed at Marion, the earliest settlement, which produced excellent crops, although continuously tilled for over half a century. Blue grass, nature's best boon for Indiana, is indigenous and readily takes possession of fence corners and untilled out lots. Attention has been given to improved breeds of horses, cattle, swine, sheep and poultry with success. This is not the temporary home or camping place of wanderers. Well appointed, comfortable residences show that the owners intend to stay. Taste, order and comfort prevail. Churches are equal to the public need, and school houses greet each other from neighboring hill tops. Greater prosperity will follow the devotion of larger areas to blue grass, if the attention required for its cultivation is given.

DRAINAGE.

For happiness, a people requires besides prosperity, sound health. Health is followed by strength and intelligence. Morality is a consequence. These are the foundations of the republic. The tile-maker achieves all these; gives annually ten to one hundred per cent. profit; insures health, strength and good morals; is the evangelist of progress. In this county his work is a work of wonder. Large areas have been drained with the happiest results, with no one to complain except the doctor, who is still manly enough to bless the enemy, who, preventing disease, robs him of fees for medicine and prescriptions.

WATER POWER.

The principal streams are reliable for mills. Use is made of this power, but several sites are not occupied. At some points Flat Rock could be energised in the cheap preparation of stone for shipment. Steam is employed in distilleries and in some of the furniture and other factories.

ROADS.

Highways, passable at *all* times and seasons, are absolutely necessary for a full realization of civilization, the fruits of labor and social life. This county is richly supplied with gravel from the glacial drift, which experience has shown to be the best material known. Full supplies are drawn from sorted pits on uplands, or from the river beds. Good roads and bridges are becoming common. The citizens owe a debt of gratitude to, and should cherish the memory of, Alexander Cory, deceased, to whose pioneer efforts these necessaries of civilized life are largely due.

WATER.

Water, derived from a deep, rich alluvial soil, is liable to contain organic matter. This often produces blood poisoning, which results in a weakened vitality that invites malarial and inflammatory symptoms, and develops zymotic disease. Water from the skies preserved in cisterns is pure and healthy, and below the glacial drift or "blue clay" is a general supply of great purity. As more than three-fourths of diseases and pains are avoidable, these sources of supply call for thoughtful attention.

TIMBER.

This district was originally clothed with a thick, heavy forest. Much has been removed, but enough, and more than enough, remains, although soft woods are pretty well gone. Near Marietta black walnut was the prevailing forest tree, and miles of rail fence was observed, made of this valuable material.

CLAY.

Fluviatile and lacustral clays occur all over the county, affording abundant supplies for bricks, drain-tiles etc. The quality is good.

BUILDING STONE.

This material is an important element of industry and wealth. The supply is inexhaustible. The quality meets with the favor of engineers, architects and builders, and the demand, already large, is constantly inncreasing. The Niagara limestones are regularly bedded, consequently cheaply quarried, easily broken to dimension and ready dressed at top and bed for use. These advantages are favorably considered by builders, and create a vigorous demand. Flags of any size that can be transported may be obtained. Further particulars are given in local details of the Lowe and Scanlan quarries.

Car Loads of Stone from St. Paul, Indiana, for Five Years.

TO	1877	1878	1879	1880	1881	Total.
Indianapolis	620	409	1,027	812	442	3,310
Other places in Indiana	387	239	608	482	909	2,625
Ohio	190	176	297	205	226	1,094
Illinois	...	2	...	2	5	9
Kentucky	2	...	...	4	...	6
Total	1,199	826	1,932	1,505	1,582	7,044

A car load of stone contains about 6 cubic yards, or 162 cubic feet.

LIME.

This is extensively calcined at St. Paul for shipment. It is strong, "hot" lime, used for masonry, etc., and also for purifying at the Cincinnati gas works. At Geneva a stone occurs in heavy beds, which is soft and easily quarried, cheaply calcined, furnishing a cool slow setting lime. It is fully equal to the best, and will command the attention of manufacturers.

Car Loads of Lime from St. Paul, Indiana, for Five Years.

TO	1877	1878	1879	1880	1881	Total.
Indiannapolis	28	20	52	60	40	200
Other places in Indiana	26	18	48	55	62	209
Ohio (Cincinnati only)	105	115	178	180	185	763
Total	159	153	278	295	287	1,172

A car load of lime contains about 325 bushels.

HEALTH RESORT.

The hot wells at Shelbyville, and at Barlow's Mills, are worthy of investigation. They are not now accessible, but if, on examination, they still afford a supply of thermal white sulphur water, they will prove a health giving boon, with accessories in the way of comfort not to be found in the distant regions of the south and west.

THANKS.

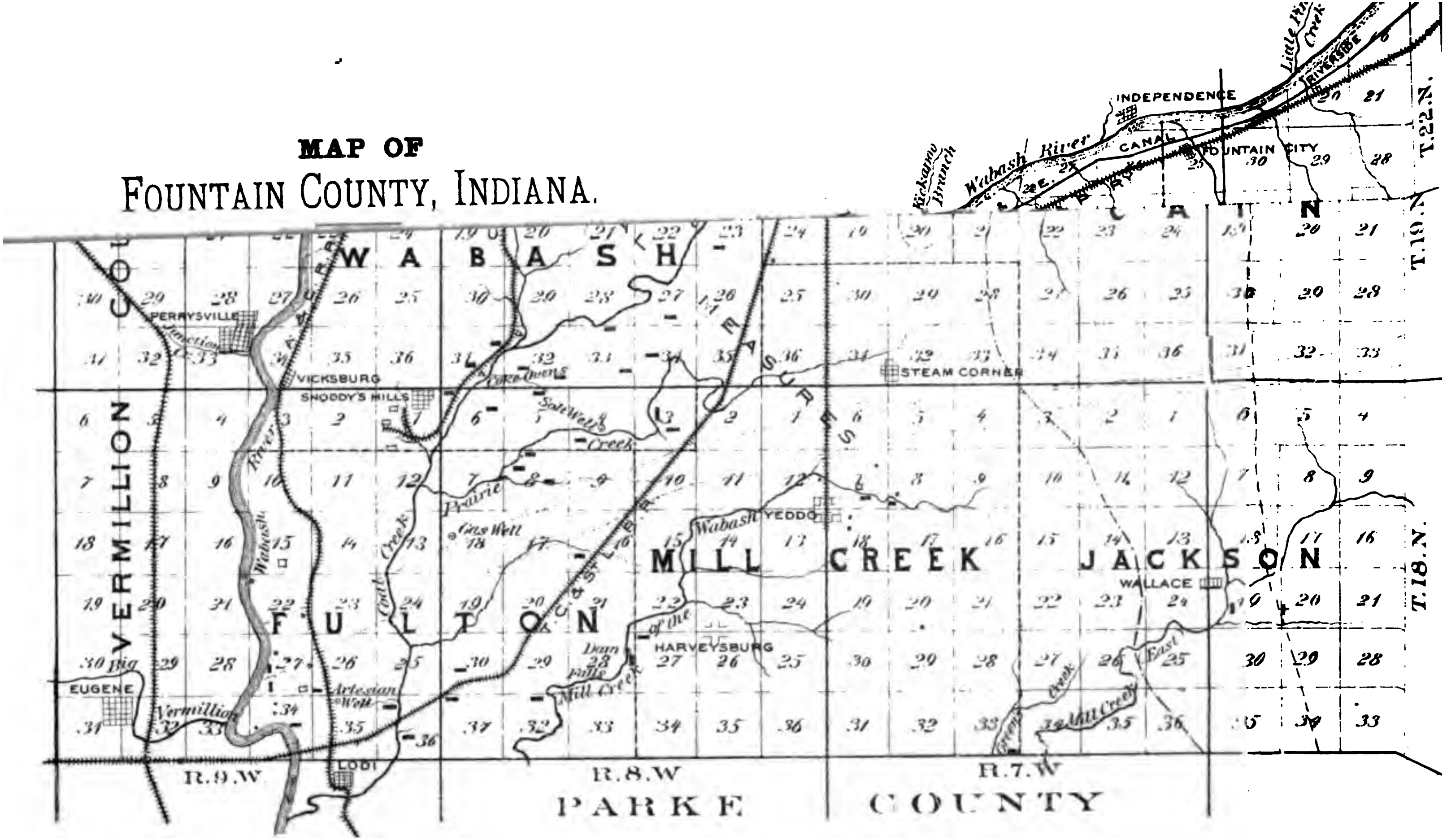
Acknowledgments are due to all the citizens for co-operation and assistance. Thanks for special favors are due to Dr. F. W. Howard, Dr. J. W. Howard, George Wright, John Nading, Dr. Jones, Dr. R. R. Washburn, J. T. Duty, Dr. W. G. McFadden, John H. Leefers, David Louden, Judge Majors, O. J. Glessner, and many others. Acknowledgments are made to R. H. Bishop, railroad agent at St. Paul, and to the officers of the C., I., St. L. & C. and of the J., M. & I. railroads for transportation, tables of elevation and every needed help.

NOTE.—The last report (1878) of Prof. E. T. Cox, State Geologist, was numbered 8th, 9th, 10th. Consequently it is suggested that this report (1881) should be numbered as the "Eleventh Annual Report of the State Geologist."

JOHN COLLETT. State Geologist.

MAP OF

FOUNTAIN COUNTY, INDIANA.



FOUNTAIN COUNTY.

GEOLOGY, GEOGRAPHY, ETC.

By Ryland T. Brown, M. A., M. D.

HON. JOHN COLLETT, *Chief of the Indiana Department of Geology and Natural History*:

SIR:—Herewith I present you my report of the work assigned me by you, and with it please accept my thanks for the assistance I received from you in the prosecution of the labor, in the form of valuable suggestions and reliable information which your acquaintance with the field enabled you to give me.

Respectfully yours, etc.,

RYLAND T. BROWN.

Fountain county is an irregular triangle, bounded on the northwest by the Wabash river, which forms a curved line, with its convex side looking towards Warren and Vermillion counties, which lie on the opposite side of the river. On the east it is bounded by Tippecanoe and Montgomery counties and by Parke on the south. The county embraces an area of about four hundred square miles; 250,000 acres, the irregular boundary on the Wabash river making numerous fractional sections, renders it difficult to determine accurately its area.

Coal creek, having a general direction from northeast to southwest, and Shawnee Creek, flowing from east to west, form the principal drainage of the county. They both discharge into the Wabash river, though the mouth of Coal creek is in Parke county, a short distance below the line dividing the two counties.

Jackson township, in the southeast corner of the county is drained by Mill creek, which is tributary to Sugar creek, and the drainage of Mill Creek township is discharged by Mill creek of the Wabash. These, together with numerous small streams which run directly into the Wabash, afford a very perfect drainage for the greater portion of the county.

Nearly seven-eighths of the county was originally covered with a heavy forest of timber. Scott's Prairie, embracing about two square miles, is located in the southwest corner of Cain township; Shawnee Prairie lies in the northern part of Richland township, and covers an area of thirty square miles, and Osborne's Prairie, in the southeastern part of Shawnee township, occupies the watershed between Coal creek and the streams that run directly into the Wabash. It is irregular in its outline and covers a territory of about eight square miles. In addition to these a number of small prairies are located north of Shawnee creek, but since the forests have been cleared away it is difficult to define their exact location. The prairies of this county are remarkable in the fact that they have no margin of barrens or shrub timber, but generally the heavy forest marks a well-defined outline of the prairie.

The county was organized in 1826, and was named in honor of Major Fountain, who fell in the ill-fated engagement with the Indians at the river Raisin in the war of 1812. The first settlements were made near the locations of Attica and Veedersburg. The county seat was located at Covington in July, 1826, and the sale of lots took place in October following, but for several sessions, court was held in the settlement near the forks of Coal creek. In 1831 a small brick court house was built on the public square in Covington. This gave place to the present edifice in 1850, which was erected at a cost of $65,000. Fountain county, from its earliest settlement, enjoyed the advantage of an extensive river front on the Wabash, which afforded excellent facilities for exports and imports. In 1846 the Wabash and Erie canal was finished through this county and opened a free communication with the eastern cities. This gave a new impetus to the improvement of the country, resulting in a large increase of production. On the opening of this new water way Messrs. Brown, Barbee & Co., built a tram railroad from the canal to the coal mines in the vicinity of Snoddy's Mill, and for several years did an extensive business in supplying the canal towns with mineral fuel. This was the first attempt, on a large scale, at regular coal mining in the State north of the Ohio river towns. The canal did an extensive business, and the towns along it enjoyed an active trade for more than twenty years, till the canal was suffered to run down, and was finally abandoned. In the meantime the volume of water in the Wabash had so diminished that it could no longer be relied on for steamboat transportation. For a few years this arrested the improvement of the county, but in 1856 the Toledo, Wabash and Western railroad touched the northeastern section of the county, and in 1870 the Indiana, Bloomington and Western railway, traversing the central portion of the county from east to west, was completed, opening a direct communication with the capitol and its extensive network of railroads. Since that two railroad lines have been opened from Chicago to the coal fields of this county, both of which are doing an active business. In addition to these the Toledo, Cincinnati and St. Louis railroad (narrow gauge) is, at the present writing, nearly completed through the county, which it traverses from northeast to southwest.

As early as 1828, Messrs. Thomas & Elston and Wallace commenced the manufacture of salt on Coal creek, near the southern line of the county. They obtained the brine from a boring about 600 feet deep. They continued the manufacture to the great advantage of the early settlers, if not to their own profit, till the opening of the canal to Lafayette brought New York salt into competition with them, when the works suspended.

TOPOGRAPHY.

The entire surface of Fountain county is covered with a deposit of glacial drift, in some places attaining a depth of more than 100 feet. In that portion of the county lying north of Shawnee creek, the glacial phenomena are prominently marked by a line of gravel hills, sometimes rising to the hight of 250 feet above the Wabash river, and to about 100 feet higher than the general surface of the plain southeast of it. This range of gravel hills and terraces follows the general course of the Wabash river at a distance of from three to five miles from it. As this line passes towards the southwest it becomes less distinct, and is scarcely perceptible below Shawnee creek. Along the base of these gravel hills, especially on the river front, are profusely scattered bowlders, ranging in size from a few pounds to ten or fifteen tons in weight. These are all of Archæan origin, and chiefly blocks of gray granite, though well marked specimens of Dioryte, Trachyte and Doleryte were observed. This mass of loose drift material rests on a heavy bed of sandstone, interstratified with beds of shale, wholly impervious to water. This arrangement gives rise to numerous large springs of water along the river front at the junction of the drift with the underlying sandstone. These are specially abundant in the neighborhood of Attica, and from thence northeast to the county line. These springs furnish abundance of quite pure water at all seasons of the year. They are, indeed, the discharging outlets of the reservoir of water that is found everywhere in the great interior plain at the junction of the drift with the underlying rock. Southeast of this line of gravel hills on the river front, lies a valley of erosion from two to three miles wide, reaching to a low range of gravel hills parallel with the first but not continuous, nor so well marked. This glacial valley shows a depth from 100 to 130 feet as ascertained by several borings along its line. It is now filled with sand, clay and fine gravel. It enters the county on the eastern line about three miles from the northeastern corner, and passes east of Stone bluff, and a little northwest of Veedersburg, crossing Dry run and Coal creek near the junction of these streams. The former of these streams owes the peculiarity from which it derives its name to the deep bed of gravel filling this erosion. It continues its southwesterly course till it strikes the Wabash river at a point about four miles below Covington. In its lower course the bordering hills disappear, but the erosion has been traced by borings made in prospecting for coal, demonstrating that the bed-rock, which elsewhere in the vicinity is found from 20 to 40 feet from the surface, has here been cut out to the depth of more than 100 feet. This was probably an ancient bed of the Wabash river, which became obstructed at the glacial period, and the river forming for itself a new channel, this was filled with transported material.

A similar erosion, though not more than half as broad, extends from the great bend of Sugar creek below Crawfordsville, in Montgomery county, in a westerly direction, passing along the southern side of Scott's prairie, crossing the C. B.-C. railroad about a mile north of Yeddo and further west, effecting Lick branch much as the upper erosion does Dry run, formerly alluded to, connecting with Coal creek a short distance below the mouth of Lick branch. This was probably the pre-glacial bed of Sugar creek, and from Scott's prairie to its junction with the Coal creek, it has most likely cut out the coal measures to their conglomerate base. This erosion is not flanked by gravel hills, but the excavation is filled with clay and sand.

These lines of erosion are determined chiefly by the result of borings made in prospecting for coal. Experienced miners have been troubled to account for these results. A boring will frequently reveal the rock and coal in place, after penetrating thirty or forty feet of drift, while another but a few hundred feet away will find neither rock nor coal within one hundred feet. Surface indications, however, will mark out the line of these valleys to a careful observer. The surface is more uniformly level and frequently inclined to be marshy.

South of the line dividing towns 19 and 20, gravel hills almost entirely disappear, and surface bowlders become quite rare. The drift deposits, on the table lands, thin out as we approach the southern line of the county, so that wells twenty or thirty feet deep sometimes reach the rock. But while this is a general rule, it is by no means universal. The ridge between Coal creek and the Wabash, south of Snoddy's mill, gives indications of a deep drift composed of a sandy clay, in places strongly colored with iron; while the rock has been reached at Newtown, on Shawnee prairie, at forty feet below the surface.

The general surface of the country west of Coal creek and north of Shawnee creek, is undulating, and sometimes the face of the hills looking towards the Wabash river rises quite abruptly, so as to give to that section of the county a broken and hilly character. From a few miles above Attica to a short distance below Portland, the Wabash has cut its way through the great sandstone base of the coal measures; and its tributaries, for three or four miles of their lower course, cut deep gorges through this rock which present bold, and sometimes perpendicular bluffs. Along Shawnee creek above the feeder dam these rise to the height of seventy-five feet; and from some distance above the mouth of Shawnee to Portland, is a continuous wall of sandstone from thirty to forty feet high.

The interior of the county is an elevated plain with gentle undulations and a slight general inclination to the south and west, sufficient to give drainage where the water-ways are unobstructed. A few sections of land near the southeastern corner of the county are so broken by the deep gorges of Sugar Mill creek, as to give a considerable proportion of waste land, but the greater part of the county is susceptible of cultivation by the plow.

SOIL.

The soil of that part of the county which lies on the Wabash slope is a deep, sandy loam, rich in the elements of fertility and of easy cultivation. In some localities it rests on a compact clay subsoil, at a depth of two or three feet from the surface. This character of soil is improved, in a marked degree by underdrainage. The same general character of soil obtains in the immediate vicinity of Coal creek, Shawnee creek and their larger tributaries. Receding from these, the soil gradually assumes the character of a clay loam resting on a heavy, clay subsoil. The surface of these soils is generally rich in vegetable matter, and in the more marshy portions the soil takes the character of a bed of deep, black muck. These clay soils, when thoroughly underdrained, become porous and easy of cultivation, and are very productive and durable. A scope of country, embracing the northern half of Jackson and Mill Creek townships and the southern half of Cain township, belong to this description of soil, which trait of character has greatly retarded its improvement. But the introduction of railroads, furnishing a market for the dense forest that has hitherto covered it; and underdrainage, which is now encouraged by the erection of tile factories, are rapidly transforming these woody marshes into productive farms.

MEDICAL TOPOGRAPHY.

In the early years of its settlement, Fountain county suffered much from intermittent and remittent fevers and other forms of malarious disease. These settlements were generally made near the Wabash river, or its larger tributaries, and occupied the bottom lands or the adjacent bluffs. The mass of half decayed vegetable matter, of which the soil was composed, had been held in this condition by the dense shade of forest trees, undergrowth, shrubbery and weeds. When these were removed and the air and sunlight freely admitted, decomposition went on at a rapid rate, and the soil sent up reeking volumes of poisonous gases that bred a pestilence among the pioneer cabins. It was soon discovered, however, that settlers on the more elevated and less fertile lands were reasonably exempt from this malaria; and even the rich bottom lands were soon tamed down by cultivation, and except where the stock of undecayed vegetable matter was renewed by the annual overflow, the bottom lands became quite exempt from malarious diseases. The undrained table lands are now subject to visitations of billious and typho-malarial fevers in the late fall and early winter months; but the river and creek margins, away from overflowed bottoms, are now rather remarkable for their exemption from malarious diseases. The flat summit lands, when properly underdrained, are entirely free from malarious tendencies. This county in its early years was widely known as the seat and center of that mysterious disease known as

MILK-SICKNESS.

It is a special form of *gastro-enteretis*, consisting of an acute inflammation of the muscular coat of the stomach and intestines. The disease affects ruminating animals, and those that feed on the milk, butter or flesh of these, when affected with the disease, whether it be man or the lower animals. The prominent symptoms are acute fever, constant vomiting and obstinate constipation of the bowels. Under the most successful treatment of scientific physicians nearly one-half of the attacks have proved fatal. Scarcely a neighborhood in the county, except the prairies and low bottoms, has been entirely exempt from attacks of the disease at some period in its history; though at present milk sickness has nearly disappeared from the county. The remote cause of this disease is still involved in doubt. Medical men of good scientific attainments, who have had opportunities for observing the disease for twenty-five years, fail to agree as to its cause, but concur in the fact that the disease is confined to those who have eaten of the flesh, butter or milk of infected animals, and that this infection is confined to animals that feed in certain localities, noted for a dense shade, that perfectly excludes the sunshine; but at the same time it is admitted that all thickly shaded jungles are not infectious. But if science has failed to detect the remote cause, practical observation has done what is better. It has demonstrated that if the forest shade be cleared away and the ground set in blue grass, or in other cultivated grasses, the most poisonous spots become perfectly healthful. To exterminate this fearful disease, nothing more is necessary than to feed the stock of the farm on grass grown on cleared and cultivated pastures.

The general health of this county will be greatly improved when the flat clay lands are thoroughly underdrained. This will not only remove stagnant water, but it will dry the superficial springs and shallow wells, and compel people to seek a supply of purer water at a deeper level, or from the purer source—the clouds.

GEOLOGY.

The underlying rocks in the eastern and northeastern parts of Fountain county belong to the sub-carboniferous members of the Carboniferous formation, while the remainder of the county is embraced in the coal measures proper. The deep deposit of drift material renders it difficult to designate at all points the exact line separating these members of the geological scale. A heavy deposit of coarse grained sandstone, the equivalent of the "Mill Stone Grit" of the English geologists, and in this country, frequently designated as the "Conglomerate Sandstone," forms the base on which the coal seams rest. The eastern outcrop of this sandstone may be assumed as the margin of the coal measures, and all east of that line may be referred to the sub-carboniferous. This line enters the county from the south near the southeastern corner. Heavy bluffs of conglomerate form the narrows of Mill creek a short distance south of Wallace, in Jackson township. North of that village the rock disappears beneath the drift, but crops out again on Clifty creek near the northern margin of Scott's prairie, and is fully developed in the heavy bluffs of the east fork of Coal creek at Hillsboro'. It again appears at Dry run in sec. 33, town 19, range 7, and at Stone Bluff in sec. 8, town 20, range 8. After disappearing for about five miles, the conglomerate is exposed again in Shawnee creek near the junction with Little Shawnee, and from thence to the mouth of the creek. The most easterly exposure of this rock on the Wabash front is at the sandstone quarry in section 32, township 21, range 7.

In considering the geology of Fountain county in detail we will recognize the civil township, but we will indicate special localities by the original survey of town, range and section.

DAVIS TOWNSHIP

Occupies the northeastern part of the county, and its surface drainage is, principally, by small streams discharging directly into the Wabash. These expose a shaly sandstone with nodules of iron distributed through it, or inter-stratified in the form of bands from half an inch to two inches thick. On Turkey run, in section 33, township 22, range 6, we have this section.

Turkey Run Section.

Shaly sandstone with bands of iron ore	10 ft.
Calciferous sandstone (hard)	6 ft.
Black bituminous shale, with iron nodules	12 ft.
Total	28 ft.

Some of these nodules would weigh a ton or more, and contain from 40 to 50 per cent. of iron. The calciferous sandstone above the shale is compact, uniformly stratified, and will furnish a reliable building material. The iron is not in sufficient quantity to justify the erection of works to smelt it, but when blast furnaces are erected in the coal field southwest of this, these nodules and bands will be required to work the specular ores of Lake Superior or Iron Mountain. We have already alluded to the profuse distribution of bowlders at the foot of a line of gravel hills that face the river front. In some places these are so thickly scattered as to interfere with cultivation.

The southeastern quarter of the township is a level plain, occupying the great valley of erosion, and is drained by superficial streams emptying into Shawnee creek, which touches the southwestern corner of the township, but does not expose the underlying rock till it strikes the western side of the erosion two or three miles below the corner of Davis township.

LOGAN TOWNSHIP

Lies west of Davis, and with the exception of two square miles at the southeastern corner, where Shawnee creek touches it, the drainage is directly into the Wabash river, by means of small rivulets, which carry the water of numerous springs that break out at the junction of the drift deposit with the underlying rock. These ravines, in their lower course, expose the rock, and often form deep chasms with perpendicular walls. The upper part of the river front, for the distance of two miles, is a repetition of the shaly sandstone of Davis township. Between this and the overlying conglomerate is interposed twenty-five feet of compact clay shale, which is imperfectly stratified. After diligent search the only fossils obtained were a specimen of *Taonurus colletti*, and some fragments of coral. The most remarkable feature of these several formations, including the conglomerate sandstone, is the absence of any well preserved organic remains by which we may accurately determine our geological horizon. The conglomerate sandstone by its position and lithological character gives us a well defined base to reckon from. The clay shale with its fragments of coral, and its characteristic fossil (*Taonurus colletti*), as well as its geological position, marks it as the representative of the Chester sandstone, and the thinly stratified sandstone below it should be referred to the same age. The calciferous sandstone of Turkey run lacks only a characteristic fossil to warrant its classification with the Keokuk member of the sub-carboniferous limestone.

In section 33, township 22, range 7, an outcrop of conglomerate sandstone occurs which has been extensively quarried for building purposes, but from some cause appears to be abandoned at present. In the construction of the Wabash & Erie Canal, rock from this quarry was extensively used; and after the completion of that work, stone was quarried here and distributed by boats to the various towns between this and Toledo, where sandstone was preferred by builders. In descending the Wabash river it is the first sandstone fit for building purposes which was found convenient to the canal. That early means of transportation is no longer available; but the Toledo, Wabash and Western railroad passes in the immediate vicinity of the quarry, and could be very readily made available for transporting stone. It is a coarse-grained sandstone, of a light gray color, though sometimes slightly tinged red with the peroxide of iron. It lies in uniform strata from one foot to four feet in thickness. It is quite soft while retaining the quarry moisture, but on seasoning it acquires a good degree of hardness. It has a vertical and a horizontal line of cleavage, and splits readily into right-angled blocks of any convenient size for building purposes. It is especially adapted to heavy masonry, such as culverts, bridge abutments, mills, factories, etc. On account of its softness in the quarry, many persons doubt its durability, but they have only to examine it in cliffs and other natural exposures, where it has resisted the elements for centuries, to be convinced of its reliability as a building material. We were informed that at present a large supply of this rock is obtained from quarries on the opposite side of the Wabash river. Indeed, we saw numerous car loads of this stone on the railroad track and in transit for various points. Logan township has a heavy stock of undeveloped wealth in this conglomerate sandstone, which may be quarried at several other points than that named, for it is the underlying rock of nearly the entire township. Besides a very productive and durable soil, and this building material, no other mineral source of wealth need be looked for in this township.

SHAWNEE TOWNSHIP

Lies south of Logan, and its drainage is effected chiefly by Shawnee creek, which enters the township near the northeastern corner, and running a westerly course, it joins the Wabash river near the northwest corner of section 22, town 21, range 8. It is a stream of considerable size, having its source in Tippecanoe county. It was once considered a valuable mill stream, and was used as a feeder for the Wabash and Erie canal; but the ponds and sloughs near its source having been drained and their channels deepened so that the water from the spring rains are discharged immediately, now the stream shrinks in the early summer months so as nearly to destroy its value as a water power the remainder of the year. Little Shawnee, a large tributary of the main stream, takes its rise in Montgomery county, and after traversing the breadth of Richland township, it enters Shawnee near the middle of its eastern line, and bearing northwesterly, it forms a junction with Big Shawnee, about two miles above the mouth of that stream.

The rock exposed in both these streams, above their junction, is the same Chester sand stone exposed in the ravines in Logan township. It has, perhaps, a little more firmness, and is more distinctly stratified, but there is the same scarcity of fossils. Immediately below the mouth of Little Shawnee, the stream encounters the conglomerate sandstone, and cuts its way through it to the Wabash, forming bold bluffs, and sometimes overhanging cliffs from fifty to seventy-five feet high. This exposure presents a mass of building stone of a superior quality, and in practically inexhaustible quantities. Near the mouth of the creek, stone was quarried to a considerable extent when the canal was in operation, but since its suspension, the quarries have been abandoned. At an exposure of this stone in a branch about one mile north of Shawnee creek and near the C. B.-C. railroad, a quarry is worked at the present time. The rock obtained is from the lower strata of the conglomerate, and is peculiar from its absence of color. It is composed of grains of pure quartz, and is really indestructible; but as it lies in the quarry, the particles are loosely held together, and when quarried by blasting, the rock is so shattered as to render much of it unfit for use. This rock may be split by steel wedges, even without drilling, and the blocks thus detached will be free from quarry cracks that often ruin blocks obtained by blasting, even after they have been dressed and placed in the wall. This white stone embraces six or seven strata resting on gray shale below and capped above with a coarser reddish gray rock. These white strata range from two to three feet in thickness. This white sandstone is exposed in the north bluff of Shawnee creek in section 24, town 21, range 8. The freedom of this rock from iron, and the ease with which it may be crushed when fresh from the quarry suggests its use in the manufacture of glass.

On the farm of Dr. Whitehall, section 24 (above alluded to), a bluff of conglomerate sandstone is exposed on the northside of Shawnee, for the distance of three-fourths of a mile. The bluff has an average height of about sixty feet, and the face of it, though somewhat irregular, is nearly perpendicular at all points. The stratification is finely exposed, showing a range of strata from one to six feet thick. The upper members are stained with iron peroxide to nearly a brick red color, but descending the bluff the tinge becomes less distinct till we reach the white series at the base. A short distance east of this bluff is an outcrop of the sub-conglomerate coal seam. It is irregular, ranging from ten inches to two feet thick. It has a roof of bituminous shale and rests on a fine bed of fire clay. This clay was observed at a point nearly opposite Dr. Whitehall's house, but the coal was absent. Though this coal seam is thin, yet the excellent quality of the coal will probably justify mining the larger pockets where the seam thickens to two feet, and especially if the fire-clay can be utilized. A similar outcrop of sub-conglomerate coal shows itself about a mile north of this, and but a short distance west of the C. B.-C. railroad.

Shawnee township has a river front on the Wabash of about four miles, the entire length of which is a wall of conglomerate sandstone from twenty-five to forty feet high. The bed of the abandoned canal lies at the foot of this bluff, and is now occupied by a railroad that is designed to run on the canal line from Attica to Terre Haute. This will afford excellent facilities for marketing this very durable and cheap building material when its architectural value shall be understood, and that will be when architects abandon the fallacy that the durability of a stone is measured by its hardness. Coal creek, in its great bend, passes through three sections of Shawnee township at its southeast corner, but does not cut through the drift so as to expose the rock at any place. The deposit of glacial drift is not so deep in this township as it is further north, and both gravel hills and northern bowlders are scarce. The great glacial erosion passed along the eastern side of the township, leaving its usually level surface, but its margin of gravel hills has almost entirely disappeared. The township is well drained and watered, and has a soil of great fertility. The bowlder drift, about twenty feet deep, very uniformly rests on compact blue clay from twenty to forty feet thick, lying on the bed rock, with usually a deposit of coarse gravel two or three feet thick interposed. Above this clay the common supply of water for domestic purposes has heretofore been obtained. But a more perfect surface drainage of the country is rapidly drying up these reservoirs, and the shallow wells in dry seasons fail, but by penetrating the clay to the lower gravel an inexhaustible supply of good water can almost invariably be obtained. When the supply of water for domestic purposes shall be generally drawn from this lower reservoir the health of the people will be materially improved. These remarks apply equally to

RICHLAND TOWNSHIP,

Which lies directly east of Shawnee. This township shows a deep drift surface, made of finer material than is exposed in the townships north of this—sand generally taking the place of gravel. But a single surface outcrop of stone was observed in this township. This occurs at Dobe's Mill, on Coal creek, in section 10, town 20, range 7. This exposure extends along the stream but about forty rods. It is, however, clearly exposed and the strata well defined. We obtained the following section:

Dobe's Mill Section.

Drift	8 ft.
Sandstone (Chester)	10 ft. 4 inches.
Argillaceous Limestone	2 ft.
Total	20 ft. 4 inches.

Though but two feet of the lowest member is exposed above the bed of the stream, yet it has been penetrated by a boring to the depth of sixty feet in the immediate vicinity. Fossils are rather rare in this rock, but we obtain well preserved specimens of *Fenestella shumardi* and *Alorisma subcuneata*, which mark it as belonging to the Keokuk group. The stratification is parallel and quite uniform, both in the sandstone and limestone; the strata ranging from six to ten inches thick. The limestone is used in the neighborhood for cellar walls and house foundations. It contains too much clay, colored with iron proto-sulphide, to be reliable in exposed situations. The sandstone overlying it, though softer, is a more durable building material. This outcrop of stone marks the eastern shore of the great glacial erosion. In the southwestern part of Newtown, on elevated ground, a boring reached sandstone (Chester?) at the depth of thirty-nine feet. A singular phenomenon occurred at this well. The sandstone was penetrated five feet, when a copious stream of water, strongly impregnated with iron, was struck, having a temperature of 59°, while the water obtained in the drift above has a temperature of 54°. We are unable to say why the chalybeate water should be warmer than that in shallower wells; unless it may be that it rises from a great depth.

Richland township has generally a level surface, and the northern part is embraced in Shawnee prairie. The township, as its name indicates, is very fertile; but its productiveness and its health will be greatly improved by underdrainage. In its early settlement, this township was noted for the prevalence of "milk sickness," but since cattle no longer run on wild pastures, the disease has entirely disappeared.

VANBUREN TOWNSHIP

Occupies the central position in Fountain county. It is traversed in nearly its whole length from north to south by Coal creek, and two large tributaries, east fork of Coal creek and Dry run, enter it from the east. Though coal has been mined to a considerable extent near Stone Bluff, in section 24, town 20, range 8, yet we may not consider any point as being fairly within the coal field if it lies north of the line dividing towns 19 and 20. Local deposits of block coal of a good quality will be found west of Coal creek and north of this line, but being on the margin of the coal field, these will be found in detached pockets, and mining can be carried on with certainty only by borings in advance of the entries. Moreover, the deep erosions of the glacial currents have, in many places, cut out the coal where it was originally deposited in a workable seam. Several borings have been made on section 36, town 20, range 8, but these investigations were made by private parties, and in these cases the person employed to make the boring is always charged to keep the register of the work entirely private, so we found it impossible to obtain definite sections of these borings. This much, however, we learned from a source that we deemed reliable. The borings were from 100 to 150 feet deep, but no coal was found in any of them. At this we were not surprised, as section 36 lies directly in the track of the great erosion—the ancient river bed. Near the southeast corner of this section, at the foot of the hill, is a surface outcrop of block coal of good quality. The seam, for some distance, ranged from thirty to thirty-six inches thick. After being worked for several years, the enterprise was abandoned on account of the seam thinning, and in some of the entries entirely disappearing, and in many places the roof was defective.

In 1872 a shaft was sunk a few rods west of the Veedersburg cemetery, for a section of which we are indebted to Riley Helm, who was one of the workmen engaged in sinking it.

Shaft near Veedersburg.

Drift	30 ft. 0 in.
Soft sandstone	10 ft. 0 in.
Compact sandstone	15 ft. 0 in.
Bituminous shale (black slate)	5 ft. 0 in.
Block coal	2 ft. 3 in.
Fire clay	1 ft. 6 in.
Fine grained white sandstone	12 ft 0 in.
Bituminous shale (black slate)	4 ft. 3 in.
Block coal	4 ft. 2 in.
Total depth	84 ft. 2 in.

At the bottom of this shaft there was a heavy inflow of water, from which the proprietors had no pump of sufficient power to relieve it. Subsequently it passed into the possession of the I., B. & W. R. R., and was used as a water station. About 150 feet south of this and on the opposite side of a branch, a boring has been made, revealing substantially the same section. Another boring was made near the west line of section 12, and above 200 yards west—a little south—of which we obtained the following, rather indefinite, section:

Drift	20 ft.
Sandstone and clay shale	48 ft.
Black slate	2 ft.
Block coal	4 ft.
Total depth	74 ft.

As the surface of the ground rises from the shaft in the direction of the boring, and the dip of the strata being in the same direction, it leaves it doubtful whether the coal reached in this boring is the upper or the lower coal of the shaft.

Eighty rods south of Veedersburg and one hundred feet west of the C. B.-C. railroad, a boring was made several years ago, but we could learn no more about it than that ninety feet from the surface four feet six inches of "rotten coal" was found. Whether this was really coal or merely soft bituminous shale, remains in doubt. As it is, however, at the horizon of the coal at the shaft, it is probably coal in some undefined condition.

At the railroad bridge, eighty rods further south, there is an outcrop of thirty inches of very hard block coal, under ten feet of sandstone, with about one foot of shale interposed between the rock and coal. This coal has been mined from under several acres of bottom land, west of the railroad, but the seam proving irregular, and the sandstone roof disappearing, the mining has been abandoned. Entries driven under the hill west of this might reveal more uniformity of seam and a better roof.

One and a half miles southwest of this, in section 11, township 19, range 8, coal has been mined quite extensive by a horizontal drift from a surface outcrop. The seam was in most places three feet thick, but showed great irregularity—sometimes being "pinched" to half that thickness, and on this account the mine is at present abandoned. The coal is a good quality of block. In this immediate vicinity three borings have been made, but all that we could learn was that at the depth of twenty-five feet a coal seam of twenty inches thick was cut, and in each of the borings, at a distance of from eighty-six to 95 feet from the surface, four feet of block coal was found. We regret that we are unable to give a connected section of the strata in these borings, but as the register is private property we were unable to obtain it. Near the northwestern line of this section a boring was made to a depth of more than one hundred feet in drift the entire distance, marking the line of the great erosion. The twenty-inch seam of coal in these borings has a layer of compact cannel coal, from four to six inches thick, which is exposed in the bed of Coal creek, a short distance below the bridge of the C. B.-C. railroad, specimens of which are frequently washed out by freshets.

A boring has recently been made by private parties in the interest of the Toledo & St. Louis railroad, in sec. 24, town

19, range 8, which found forty inches of block coal at a depth of eighty feet. This renders it probable that the lower seam of block coal may be mined, generally, in that part of VanBuren township which lies south of Veedersburg and west of the C. B.-C. railroad; but owing to the irregularity in the seams so near the margin of the coal field, we would not advise the sinking of shafts without first making careful explorations by boring.

An outcrop of conglomerate sandstone occurs on Dry run near the north line of sec. 33, town 20, range 8, which, if properly quarried, will furnish an excellent and very durable building material. A similar outcrop occurs at Stone Bluff in section 10, in the same town and range as the above. In neither of these outcrops have quarries been regularly opened, though stone has been obtained, to a limited extent, for house foundations, etc. The people have not yet learned its value.

TROY TOWNSHIP.

This township has a large river front, as it lies in the great bend of the Wabash, at the lower end of which is located the town of Covington, the county seat. Though Troy township lies chiefly within the coal field yet it has but little workable coal. In the southeastern corner the coal is cut out by the great erosion which forms a junction with the Wabash river from three to four miles below Covington.

About one and a half miles south of Covington, and near the line between sections 1 and 2, town 19, range 9, is an outcrop of block coal, which has been worked in former years, but appears now to be abandoned. The seam ranges from twenty inches to three feet thick, but is very irregular, and where it has been worked the roof is defective. This last defect would, probably, be remedied by extending the entries under the hill to the east, but perhaps the irregularity in thickness of seam would render mining unprofitable. The same seam appears in the railroad cut about two hundred yards east of the station, at Covington, where it shows but sixteen inches of coal.

In a ravine but a little distance east of the old canal bed, in section 12, town 19, range 9, there outcrops a seam of bituminous coal three feet thick. When the canal was in operation this coal was mined quite extensively, but the work is now abandoned. The coal is similar in quality to that so extensively mined near Snoddy's Mill, which will be described hereafter. At the time of the oil excitement some parties made a boring, near this coal drift, in search of oil. At a depth of about one hundred and seventy-five feet they abandoned the enterprise, but left a fine flowing well of very pure water. We were unable to find the parties who made this boring, and therefore could not obtain a section of it.

The elevated ground in the vicinity of Osborn's Prairie may possibly have the lower seam of block coal underlying it, but the near proximity to the margin of the coal field will, probably, render the seam irregular, and the deposit of coal, in pockets, rather than in a continuous seam. Boring in sections 20, 21 and 22 would settle this question.

Troy township has a productive soil, adapted to a wide range of crops, and the northern part of the township lies admirably for cultivation. The southern part is somewhat broken by the deep valleys of the tributaries of Coal creek and the Wabash; yet there is but little land in the township that can not be conveniently plowed.

WABASH TOWNSHIP

Lies directly south of Troy, and has a river front of five miles. Coal creek cuts the township diagonally from northeast to southwest; and Graham's creek, a large tributary, which has its source in Osborn Prairie, traverses the northern part of the township. These, with the hills along the river front, render the surface of the country somewhat broken.

In section 31, town 19, range 8, in section 6, town 18, range 8, and in section 1, town 18, range 9, are located the rather celebrated "Stringtown" coal mines. These mines were opened by Brown, Barbee & Co., as early as 1845, and the succeeding year a tram railroad was constructed over the ridge, to the Wabash and Erie Canal; and coal was furnished from this point to supply the demand of all the towns along the canal to Toledo. The abandonment of the canal suspended mining here and the work lay idle until 1870, when the C. & Eastern Illinois railroad constructed a branch to this point, and mining was commenced chiefly in the interest of the North Chicago Iron and Steel Works. At present (June 20, 1881) three horizontal drifts and three shafts are in active operations. The coal is a semi-block, but too bituminous to work in smelting iron without coking, but makes an excellent article of coke, and is quite free from sulphur. We regard it as the equivalent of coal K of Prof. Cox's classification. The seam ranges from five to six feet thick, and is quite uniform. On section 31, Soliday & Co. are working thirty hands in two drifts, with five feet of coal. The shale roof of these entries are very rich in well preserved fossils of the coal vegetation. Of these we obtained specimens of the *Pecopteris lonchitica*, fronds of *Sphenopteris crenata*, *Neuropteris hirsuta*, and fragments of stems and fronds of calamites (species undetermined). On section 6, Ogden Bros. are working a drift in a seam five feet thick of coal K. On section 1, Trunky, Purdee & Co. work a shaft forty feet deep, mining a seam of K six feet thick. This company works fifty hands. S. W. Phelps & Co. have a shaft fifty feet deep on section 1. The coal is six feet thick and similar in quality to the neighboring mines. This shaft employs one hundred hands in summer and two hundred in winter, and raise from one fifty to three hundred tons of coal daily. On the same section, and three hundred yards southwest from the last named shaft, the Fountain County Coal Mining Company are operating in a shaft one hundred feet deep, working six feet of coal K, with a force of one hundred and fifty hands. The entire output of this group of mines is at this season about five hundred tons daily. The North Chicago Iron and Steel Company has just completed and put into operation twenty-five coke ovens for economizing the coal slack from these mines. The cost of these ovens with the machinery necessary to operate them was $150,000. The experiment is working satisfactorily.

On sections 4 and 5, township 18, range 8, there is an outcrop of coal K, about 4 feet thick, which has been mined to a limited extent for neighborhood use. This outcrop is on the bluff south of Prairie creek. We found no indications of this coal seam between Coal creek and Prairie creek, the general level being below its elevation. Near the north line of section 5, and in section 3, township 18, range 8, are outcrops of block coal in seams from thirty to thirty-six inches thick; and on sections

33, 34, 27 and 23, are outcrops of block coal, the seams ranging from three feet to three feet ten inches in thickness. The coal is of good quality, and the general uniformity in the outcrops in the ravines on the east side of Coal creek from above Cade's Mill to a point nearly opposite Snoddy's Mill, gives ground to infer that this upper block coal seam has lost much of the irregularity which marked it in the neighborhood of Veedersburg. At Cade's Mill (section 27) there are indications that the lower block coal lies but a little distance below the bed of Coal creek, but no borings or excavations have yet been made to ascertain that matter.

In 1830 Mr. Jarred from the Kanawha salt regions in Virginia, made a boring on the north side of Prairie creek in section 4, township 18, range 8, for the purpose of obtaining brine for the manufacture of salt. No very definite register of the boring was kept, but we were fortunate in obtaining from Jesse Jarred (a son of the proprietor, who assisted in the boring) the following general notes:

Section at Jarred's Well.

Drift	40 ft.
White sandstone	10 ft.
Black slate and coal	10 ft.
Fire clay and soapstone	12 ft.
First brine at	72 ft.
Total	144 ft.

This brine not being satisfactory, either in quantity or strength, the boring was subsequently continued to the depth of 1,004 feet, tapping several veins of brine in that distance. Salt, to a limited extent, was made here for several years, but the proprietor lacked capital to compete with Thomas & Co., who were operating a salt furnace about eight miles south of this, near the mouth of Coal creek. The only point of importance in this boring is the demonstration of a coal seam below that in section 3, one mile east of this. But in those early days the notes of boring did not discriminate between bituminous shale and coal, and how much of the ten feet in the above section was the one, and how much the other, it is imposible to determine without repeating the boring.

FULTON TOWNSHIP

Occupies the southwest corner of Fountain county. It has a river front of five miles, and is traversed from north to south by Coal creek, while Wabash Mill creek cuts across the southeast corner for a distance of two miles. These streams render Fulton township the most broken and hilly of any in the county. The northern half of the river front is composed chiefly of drift hills, rising from one hundred to one hundred and fifty feet above the river. At a westward bend of the river, near the southern line of section 22, town 18, range 9, a bayou continues the direction of the river above and cuts off a considerable territory of elevated land, presenting a bold and rocky front towards the river. The bayou or "swale" has a width of from two hundred to four hundred yards, and gives evidence of having once been the bed of the Wabash; and even now it requires but a moderate rise of the river to throw a strong current through it. This detached piece of high land is known as "Silver Island," and was a notable place in the early days of Wabash navigation. It is the highest point on the river shore where coal is observed cropping out. Near low water mark, at the base of a bluff, about forty feet high, at an abrupt bend of the river to the right, there is an exposure of coal, seam K, with its characteristic limestone roof, bearing marine fossils. From this rock we obtained *Productus semireticulatus* and *Productus longi-spinus*. The coal at this point has an average thickness of about four feet. Above this three other seams occur, ranging from twenty inches down to ten inches thick. These probably represent L and M of the Indiana series. The coal in the lower seam is of a fair quality, though its exposure to the river in high water has injured it at the outcrop. On the east side of the island an outcrop of coal K occurs near the southwest corner of section 26, town 18, range 9, on the land of N. Thomas. This coal was quite extensively worked when the canal was in operation, and gained the reputation of being a superior quality of coal. The works are now abandoned and the entries filled up. The seam is about four feet thick. A shaft was once sunk a few rods west of the line between sections 26 and 27, on the land of H. Randolph, reaching the same seam of coal, but owing to the abandonment of the canal, this shaft was not worked to any considerable extent. Extensive borings in search of coal have lately been made on Silver Island, but as these were made in the interest of private parties, we are unable to obtain details. In general terms, we learned that the coal on the island is irregular—in some places reaching a thickness of seven feet. The upper seams, L and M, are not in any place workable. On the northern part of the island there are seven surface outcrops of this coal that have been worked, none of which was less than four feet thick. A shaft, also, was once sunk to four feet of this coal on the upper part of the island. Near the Coal creek bridge, on the Toledo, Cincinnati & St. Louis Railroad, there are several outcrops of coal K where the seam ranges from three to five feet thick. These outcrops are in sections 36, town 18, range 9, and in sections 31, 30 and 20, in town 18, range 8. North of this the eastern erosion has cut out the coal in a belt from half a mile to a mile wide. Beyond this, coal K appears again on sections 7 and 8, town 18, range 8, along the ravines running into Prairie Creek from the south. These mines have not been worked sufficiently to determine the character of the coal, nor the thickness of the seam with accuracy, but both look favorable, and we predict a field of profitable coal mining between Coal creek and Wabash Mill creek, in the three southern tiers of sections in Fulton township. Though there is a considerable space between these creeks in which no coal appears—the streams being superficial—yet at the falls of Mill creek, in section 28, town 18, range 8, coal K appears in a seam four feet thick, and covered with its characteristic roof of silicious limestone. Indications of coal are seen below this on the creek. These circumstances justify the opinion that the same bed extends, with more or less regularity, under the whole intermediate space.

Sandstone of a good quality is found on the river face of Silver Island, at the point where the line dividing sections 27 and 34 strikes the bluff. The quarry is being worked at this time to obtain stone for the railroad bridge over the Wabash at the county line. Some of the strata in this quarry have a decidedly blue tinge. Rocks of this character should not be placed in exposed situations. The lighter colored strata of this quarry are entirely reliable in any situation.

In the year 1865 a boring was made near the north line of section 35, town 18, range 8, for the purpose of determining the presence of salt or other valuable mineral deposits in the strata below. The boring was prosecuted to the depth of 1,155 feet, at which point a very strong flow of mineral water was encountered which arrested the boring. At several points in the progress of the work veins of brine were struck, but none of these proving satisfactory to the company, the boring was continued. We subjoin a condensed report of the strata penetrated by this boring, as the same were noted at the time.

Section in the Lodi Artesian Well.

Drift	5 ft.	0 in.
Sandy shale	1 ft.	3 in.
Shale, with iron nodules	2 ft.	3 in.
Clay	2 ft.	0 in.
Fossiliferous limestone	2 ft.	0 in.
Shale	8 ft.	0 in.
Coal	1 ft.	0 in.
Fire clay	3 ft.	0 in.
Coal	1 ft.	0 in.
Shale, with iron nodules	1 ft.	6 in.
White sandstone	12 ft.	6 in.
Sandstone and limestone	7 ft.	6 in.
Argillaceous sandstone and thin coal seam	10 ft.	0 in.
White clay sandstone	8 ft.	0 in.
Thinly stratified sandstone	13 ft.	6 in.
Sandstone, with iron ore	3 ft.	3 in.
Sandy shale	12 ft.	7 in.
Dark unctuous clay	2 ft.	5 in.
Shale, with thin coal	3 ft.	4 in.
Brown sandstone and shale	10 ft.	1 in.
Cream colored sandstone	5 ft.	0 in.
White mica sandstone	6 ft.	0 in.
Fine grained sandstone	9 ft.	0 in.
Shale	2 ft.	8 in.
Clay shale	3 ft.	2 in.
Compact shale	6 ft.	3 in.
Black shale	9 ft.	0 in.
Soft clay shale	5 ft.	0 in.

Compact shale	14 ft.	6 in.
Sandstone	31 ft.	11 in.
Sandy shale	39 ft.	4 in.
Hard quartz sandstone	2 ft.	3 in.
Sandy shales	60 ft.	0 in.
Fine grained sandstone	31 ft.	2 in.
Hard sandstone	10 ft.	3 in.
(Brine 2° B.)		
Fine grained sandstone	5 ft.	0 in.
Sandy shale	7 ft.	1 in.
Unctuous shale	12 ft.	1 in.
Hard shale, with iron ore	12 ft.	3 in.
Sandy shale	53 ft.	7 in.
Hard sandstone	10 ft.	9 in.
Sandy shale	43 ft.	0 in.
Sandstone and shale	9 ft.	10 in.
Sandy shale	49 ft.	1 in.
Flint nodules in sandstone	8 ft.	2 in.
Sandy shale	45 ft.	9 in.
(Brine 5° B. 610 ft.)		
Compact sandstone	10 ft.	3 in.
Fine grained sandstone	54 ft.	7 in.
Clay shale	11 ft.	2 in.
Fine grit shale	60 ft.	9 in.
Compact silicious rock	1 ft.	0 in.
(Brine 6½ B.)		
Soft clay shale	7 ft.	3 in.
Fine grit shale	5 ft.	3 in.
Compact sandstone	3 ft.	0 in.
Soft sandstone	16 ft.	10 in.
White sandstone	6 ft.	0 in.
Sandstone, with thin layers of quartz	35 ft.	7 in.
Soft sandstone	9 ft.	4 in.
Shale and clay	19 ft.	4 in.
(Brine 8½° B 880 ft. 2 in.)		
Tenacious clay	8 ft.	7 in.
Shale, with thin bands of sandstone—Knobstone	26 ft.	7 in.
Lingula shale (black slate)—Devonian	90 ft.	1 in.
Hard, crystalline limestone—Devonian	20 ft.	1 in.

Coraline limestone—Devonian	12 ft.	0 in.
Magnesian limestone, with chert—Devonian	18 ft.	8 in.

At this depth (1051 feet) struck a flow of sulphur water that discharged with great force at the rate of 1500 barrels per day. Boring was continued through—

Hard silicious rock—Upper silurian	45 ft.	10 in.
Soft fine limestone—Upper silurian	5 ft.	0 in.
Compact limestone—Upper silurian	10 ft.	0 in.
Yellowish gray limestone—Upper silurian	6 ft.	0 in.
Hard blue limestone—Lower silurian	14 ft.	6 in.
Drab crystalline limestone—Lower silurian	14 ft.	6 in.

The flow of water increasing, the boring was suspended at a depth of 1155. The temperature of the flowing water at the surface of the earth is 70° F. It emits a very strong odor of hydrogen sulphide, and has a brackish, not unpleasant taste. The flow of the water continues with little or no abatement to the present time. It has made a deposit of calcium sulphide around the well, and on everything with which the water comes into contact. An analysis of the water was made by J. C. Pohle, M. D., Analytic Chemist, 489 Broadway, New York, which we give below:

One gallon of Lodi water contains 7.94 cubic inches of hydrogen sulphide gas, and 673.937 grains of solid substance, consisting of—

Chloride of sodium	502.464	grs.
Chloride of calcium	47.928	grs.
Chloride of magnesium	53.540	grs.
Sulphate of lime	55.553	grs.
Sulphate of potassa	.804	grs.
Sulphate of magnesia	3.260	grs.
Sulphate of soda	2.135	grs.
Bi-carbonate of lime	1.104	grs.
Silicic acid	.520	grs.
Phosphate of lime	.345	grs.
Sulphide of lime	1.200	grs.
Nitrogenous matter (organic)	.500	grs.
Sulphur, mechanically mixed	.500	grs.
Bromide of magnesia	a trace.	
Total	673.937	grs.

The character of this water and that of the celebrated White Sulphur Springs of Virginia, is nearly identical. The water of the Lodi well contains a little larger per cent. of chloride of sodium (common salt) than the Virginia Springs. This is, perhaps, owing to the copious flow of salt water found above the sulphur vein. When the railroads now in process of construction are completed, this well will certainly become a noted resort for invalids affected with chronic diseases of the glandular system, or affections of the skin.

In section 18, township 18, range 8, on the farm of J. Burnside, a boring was made in May, of the present year, for the purpose of obtaining a supply of stock water. The boring penetrated drift material to the depth of 100 feet, where a soft clay shale was struck, and coal was found at the depth of 110 feet. On penetrating the coal two feet a strong flow of inflammable gas took place, which continues to the last advices.* The gas, when we examined it (July 22, 1881), was flowing in a strong jet through an aperture three-eighths of an inch in diameter, giving a hissing sound. It burns with pale yellow flame, and gives an intense heat with no odor, neither in burning nor before. It is evidently carbide of hydrogen, the much dreaded "fire-damp" of the miners. So far as our knowledge extends, it is a rare occurrence in connection with our coal seams in Indiana. It may be economized for lighting and heating purposes.

MILL CREEK TOWNSHIP.

This is a district of level, rich soil, with defective drainage. The southern part of the township depends on Wabash Mill creek, and the northern on Prairie creek, for drainage, and both these are surface streams. It was originally covered with a dense forest of oak, beech, ash, hickory and elm timber, and much of it remains in the same condition yet. When cleared of its forest and properly drained, this soil will be very productive.

Coal appeared at the surface but at three points in this township, though it is quite probable that, with the exception of three or four square miles in the northeast corner of the township, and a narrow belt of erosion passing nearly along the line of Prairie creek, coal will be found underlying the township generally.

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*NOVEMBER 10—The accumulation of water in the tube has arrested the flow of gas.

At a point one mile west from Harveysburg an outcrop of coal K makes its appearance at the foot of the hill on the east side of Mill creek. Coal has been taken out here, to a limited extent, by stripping, but as it has not been worked far enough to develop a permanent roof, we were unable to determine the thickness of the seam or the quality of the coal.

From this point to section 7, township 18, range 7, a distance of five miles, the stream nowhere cuts through the drift so as to expose the underlying rock. In section 7, at a point about eighty rods east of the new railroad town of Yeddo, coal K appears, covered by its limestone roof. Within the last year extensive explorations for coal have been made in this vicinity. These borings, chiefly on sections 7 and 18, reveal the coal at depths ranging from forty to seventy-five feet, and in seams from three to five feet thick. A shaft has been sunk eighty rods northeast from Yeddo, of which we obtained from Col. Beach the following section:

Section in the Yeddo Shaft.

Drift	13 ft.	... in.
Silicious limestone	15 ft.	5 in.
Bituminous shale	10 ft.	10 in.
Coal (K)	4 ft.	10 in.
Fire clay	1 ft.	8 in.
Total	45 ft.	9 in.

The coal is of excellent quality, being well preserved by its double roof of limestone and shale. The limestone of this roof is packed with an abundance of marine fossils, though representing but a few species. Of these we obtained *Productus nebrascensis*, *P. longi spinus*, *P. semireticulatus*, *Spirifer cameratus* and *Athyris subtilita.* Several inquiries have been made in regard to using the heavy limestone roof of this coal, as a building material. To these we reply: It is intensely hard, and, therefore, has but little elasticity, and will not endure sudden changes of temperature, the expansion and contraction consequent on such changes will fracture the surface, and these cracks will admit water, which, on freezing, will break the rock into fragments. For use in unexposed situations, such as cellars or wells, it will answer a good purpose. Its silicious character will prevent it from slaking readily to lime, when burnt.

We confidently predict that, in the near future, when the entire line of the Chicago Block Coal road shall be finished to the lake, that a heavy coal mining business will be developed on this broad plain lying west and south of Yeddo. North of this, coal K will not be found to any considerable distance, nor would we expect it to extend east more than a mile from Yeddo, though at the county line south, it reaches three miles east, where we have a third exposure of coal K in the township. This is in section 33, township 18, range 7, being near the southeast corner of the township. This outcrop is extended for eighty rods along a tributary of Sugar Mill creek. The seam ranges from four to six feet thick and the coal is of good quality. This "bank" has been worked for more than forty years. In the early settlement of the country coal was hauled from here to Crawfordsville and other points east for the use of blacksmiths, and as a forge coal it is even now quite extensively used. Appearances indicate that at one time or another a large amount of coal has been removed from this place, though the mining has been chiefly done by stripping. Several entries, however, have been driven into the bank for a short distance, and one or two of them have been lately occupied by miners. Until quite recently the nearest railroad to this mine on a direct line was eleven miles, and much further by any accessable route. North of Prairie creek, the probability of reaching block coal at any point on the railroad, as far as to the township line, is such as will justify investigation by boring. The outcrop of block coal at "Hankin's bank," in Wabash township, is but three miles below the railroad bridge on Prairie creek, and this is evidently the upper seam of block coal, and if the lower coal is persistent and lies at the same horizon as at the Jarred salt well, it should be found about sixty feet below the upper seam, or about one hundred feet below the surface at the railroad crossing of Prairie creek. That the lower block coal passes entirely under the heavy development of K, south of Yeddo, is rendered probable by the outcrop of a four feet seam of it in Green's creek, a short distance south of the county line. But this does not rise above a probability, for it must be admitted that the block coal, at least in this northern part of the field, is neither uniform nor persistent; but the excellent quality of the coal will justify the expense of the borings necessary to place this question on a basis of certainty.

JACKSON TOWNSHIP

Lies in the southeastern corner of the county, and is drained by Sugar Mill creek and the head waters of Green's creek. The southern part of the township is quite hilly, being cut by deep ravines that are tributary to Sugar Mill creek. From the village of Wallace, for the distance of two miles southwestwardly, that stream has worn itself a channel through the conglomerate sandstone. About a mile below Wallace, the stream passes through a deep, narrow gorge, generally known as the "Narrows of Mill creek." Here, as elsewhere, this conglomorate will furnish an almost inexhaustible supply of cheap and durable building material.

In section 34, township 18, range 7, there is an outcrop of coal that may be seen in the bed of Mill creek at low water. It being covered with water and fragments of rock at the time of our examination, we were unable to determine the thickness of the seam, or with certainty, the character of the coal. From fragments that have been washed out, and from its near proximity to the conglomerate base of the coal measures, we are disposed to refer this seam to the block coal group. At several points north of Wallace thin seams of sub-conglomerate coal appear in the bed and banks of Mill creek; but, as in other places, this seam is not workable. It is probable that coal in workable seams will be found underlying the first tier of sections on the west side of Jackson township, and, perhaps, locally in the second tier.

At several points on Mill creek north of Wallace, the Keokuk member of the sub-carboniferous limestone appears, presenting well-preserved fossils of that age, among which we observed *Productus punctatus*, *P. semireticulatus*, *P. magnus*, *P. cora*, *Phillipsia bufo*, *Spirifer pseudolineatus*, *Aviculopecten Indianensis*, and *Actinocrinus lowei*.

This township was originally covered with a heavy forest, and lying beyond the reach of railroad markets, heretofore, much of the timber remains on the ground. With the exception above made, the surface of the township is level and much of it will be improved by artificial drainage. The soil is a rich clay loam, with a considerable mixture of sand, and in places strongly colored with iron. Scott's prairie touches this township in section 2, town 18, range 7.

CAIN TOWNSHIP

Rests on formations, geologically too low to furnish seams of workable coal. Thin layers of sub-conglomerate coal may be found in the East Fork of Coal creek, above Hillsboro, but they will prove of no value, and borings, or other researches for coal at a lower level will be labor lost, The surface rock is already below any workable coal seam.

At Snider's mill dam, near the line between sections 16 and 21, township 19, range 6, there is an outcrop of the sub-carboniferous limestone, with abundance of characteristic fossils, fair samples of which we were able to procure. The upper ten feet belongs to the St. Louis group, and below this is a blue shaly limestone, with Keokuk fossils less liberally distributed than are St. Louis fossils above, but both are characteristic and well marked. Of the St. Louis fossils we obtained *Spirifer keokuk* var. *Athyris hiruta*, *Aulopora gigas*, *Archimedes* (Species?) *Bellerophon sublevis*, *Eumetria verneuilanum* and a *Cyathocrinus*. We were unable to determine the depth of this Keokuk bed, as immediately above the dam the drift covers the rock, and it appears no more. Near the western line of section 16 this formation dips under the conglomerate sandstone which, for the distance of six miles, forms the bed and bluffs of the east fork of Coal creek. These bluffs, in some places, rise to the height of sixty feet. The sandstone in this locality is highly charged with peroxide of iron. Indeed, in some places the iron constitutes twenty-five per cent. of the rock, giving it the character of a silicious iron ore. These highly charged iron sandstones will be found of great service in making roads. The iron and sand, uniting with the clay, will form a very compact cement. The large proportion of iron in most of the sandstone in the vicinity of Hillsboro will impair its value as a building material. Quarries of this rock, however, may be found, embracing the lower members of this formation that are quite free from iron. Half a mile east of Hillsboro, in a ravine, is an exposure of sandstone that is nearly white, and very uniform in its stratification and compact in structure. Proximity to the Indiana, Bloomington and Western railroad, will give this rock a local value, but apart from this we desire now to invite especial attention to the adaptation of this conglomerate sandstone to architectural purposes, and especially to the erection of public buildings and other structures requiring heavy masonry. The time is in the near future when this Indiana coal field will be dotted over with mills and factories of every discription, attracted here by our cheap food and cheaper power. Then we will learn the value of a building material which can be easily quarried and readily dressed into blocks of any desirable size; and which will endure the test of time and fire. Such a rock is the conglomerate sandstone of Fountain county.

The general surface of this township is gently undulating, and though the east fork of Coal creek traverses its length from east to west, it leaves but little ground that can not be plowed. The southern part of the township, embracing the greater part of Scott's prairie, is quite flat, and will require tile draining to bring out its full fertility. The soil is a rich sandy loam, especially adapted to grain crops, though grass on it, produces well.

RECAPITULATION.

The geology of Fountain county exposes the upper members of the sub-carboniferous formation, and the lower members of the coal measures. The first consists of the Keokuk and St. Louis limestone and the Chester sandstone. The second consists of the conglomerate sandstone, the block coal series, comprising three seams, which we regard as B, C and D; and of the bituminous series we identify coals K, L and M. Fragmentary seams occur locally that may belong to higher members, but we were unable to identify them.

Overlying the shale roof of coal B, we find quite uniformly a white micaceous sandstone, of from ten to fifteen feet thick; and above the shale roof of coal K is a silicious limestone from two to twelve feet thick, abounding in marine fossils, among which we noticed *Spirifer cameratus*, *Productus semirecticulatus*, *P. nebrascensis*, *P. longi spinus*, *Athyris subtilita*, etc. The sub-conglomerate coal appears in thin, irregular outcrops at the base of the conglomerate sandstone near the junction of Little and Big Shawnee, and in a small creek about a mile north of Shawnee and half a mile below the railroad bridge. The coal is of good quality but too thin to work profitably. The available coal of Fountain county is comprised in two seams of block coal and one of bituminous coal.

The lower block coal (B) is not exposed in any surface outcrop in the county except, perhaps, near Stone Bluff in section 24, town 20, range 8, where it appears in detached pockets immediately above the conglomerate sandstone. It has, however, been reached by borings in various places south of the I. B. & W. railroad, exposing an average seam of about four feet.

The upper block coal (C) makes numerous surface outcrops on both sides of Coal creek, in the vicinity of Veedersburg, and on the east side of that stream as far south as Prairie creek. The seams range from thirty to forty inches thick. The quality of coal is generally good, but the seam is broken and irregular, and in some places entirely missing. The roof is generally of a black bituminous shale or slate, occasionally capped with a coarse, gray sandstone. In some places the roof has been entirely removed by erosion, which renders mining difficult, if not impracticable.

The surface outcrops, marked on the map in Wabash, Fulton, Millcreek and Jackson townships, are of the bituminous coal (K). The seam ranges from four to six feet thick, is quite free from sulphur and burns with a bright yellow flame, cakeing somewhat in burning, and when properly treated forms an excellent coke. The territory beneath which this seam is available in this county is about one hundred square miles. In chemical composition and general character the coals of Fountain county are identical with the block coal of Clay county, and with the Sand creek coal (K) of Parke county.

BUILDING STONE.

The outcrop of conglomerate sandstone which traverses the whole length of the county furnishes an inexhaustible supply of sandstone—very durable, easily worked and admirably adapted to heavy architecture. The outcrops of this stone at the narrows of Mill creek, near Wallace, on the east branch of Coal creek in the vicinity of Hillsboro, on Dry run, at Stone Bluff, along the Wabash front from above Attica to a point below Portland, and the bluffs of Shawnee creek from the junction of Little Shawnee to the mouth, will furnish opportunities for quarrying to advantage. Several varieties may be selected, differing in color and fineness of grain, adapting it to the purpose for which it may be needed.

Clay suitable for the manufacture of an excellent quality of brick abounds almost everywhere throughout the county, and excellent fire-clay is found at the base of the conglomerate sandstone on the Big Shawnee, and beneath each of the coal seams throughout the coal measures. Much of this is well adapted to the manufacture of stoneware, drain tiles and terre cotta work.

TIMBER.

It was not the purpose of the survey to make thorough examination of the botany of the county, but while making geographical and topographical researches, we noted the following list of trees and shrubs, which will be found to embrace the most important features of the native arboreal flora of the county.

COMMON NAMES.	BOTANICAL NAMES.
Sugar Maple	*Acer sacharinum.*
Red Maple	*Acer rubrum.*
Silver-leaf Maple	*Acer dasycarpum.*
Stinking Buckeye	*Æsculus fœtida.*
Virginia creeper	*Ampelopsis quinquefolia.*
Papaw	*Asimina triloba.*
Water Beech	*Carpinus americana.*
Shelbark Hickory	*Carya squamoso.*
Bitternut	*Carya amara.*
Swamp Hickory	*Carya aquatica.*
Mockernut	*Carya tomentosa.*
Pecan*	*Carya olivæformis.*
Hackberry	*Celtis crassifolia.*

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* The pecan is found in the Wabash bottom four miles south of Covington—the farthest point north in this State.

Bittersweet	*Celastrus scandens.*
Button-bush	*Cephalanthus occidentalis.*
Flowering dogwood	*Cornus florida.*
Round-leafed dogwood	*Cornus circinata.*
Panicled dogwood	*Cornus paniculata.*
Hazelnut	*Corylus americana.*
Scarlet haw	*Cratægus coccinea.*
Yellow haw	*Cratægus flava.*
Red haw	*Cratægus sanguinea.*
Leatherwood	*Dirca palustris.*
Beech	*Fagus ferruginia.*
White ash	*Fraxina americana.*
Water ash	*Fraxina platycarpa.*
Blue ash	*Fraxina quadrangulata.*
Swamp ash	*Fraxina sambucifolia.*
Honey locust	*Gleditschia triacanthus.*
Coffee-nut	*Gymnocladus canadensis.*
Witch-hazel	*Hamamelis virginiana.*
Ninebark	*Hydrangea canadensis.*
Butternut	*Juglans cinerea.*
Black walnut	*Juglans nigra.*
Spicewood	*Benzoin odoriferum.*
Tulip tree (yellow poplar)	*Liriodendron tulipifera.*
Black mulberry	*Morus nigra.*
Boxelder	*Negundo aceroides.*
Sour gum,	*Nyssa multiflora.*
Hornbeam	*Ostrya virginica.*
Sycamore	*Platanus occidentalis.*
Cottonwood	*Populus monolifera.*
Quakingasp	*Populus tremuloides.*
Wild plum	*Prunus americana.*
Wild cherry	*Prunus serotina.*
Crab apple	*Pyrus coronaria.*
White oak	*Quercus alba.*
Pin oak	*Quercus agrifolia.*
Water oak	*Quercus aquatica.*
Black oak	*Quercus tinctoria.*
Red oak	*Quercus rubra.*
Spanish oak	*Quercus falcata.*
Burr oak	*Quercus marcrocarpa.*

Black jack	*Quercus ferruginea.*
Dwarf sumac	*Rhus copallina.*
Poison vine	*Rhus toxicodendron.*
Wild gooseberry	*Ribes hirtellum.*
Swamp rose	*Rosa carolina.*
Prairie rose	*Rosa setigera.*
Willow	*Salix cordata.*
Prairie willow	*Salix humilis.*
Elder	*Sambucus canadensis.*
Sassafras	*Sassafras officinalis.*
Bladdernut	*Staphylea trifolia.*
Trumpet creeper	*Tecoma radicans.*
Linn or Bass wood	*Tilia americana.*
Wahoo	*Ulmus alata.*
Elm	*Ulmus americana.*
Slippery Elm	*Ulmus fulva.*
Arrow wood	*Viburnum dentatum.*
Black haw	*Viburnum prunifolium.*
Summer blue grape	*Vitis æstivalis.*
Winter grape	*Vitis cordifolia.*
Prickley ash	*Zanthoxylum carolinianum.*

ANTIQUITIES.

Though the pre-historic races left but few mounds or earthworks in this county to attest their occupancy of its territory, yet we are not without evidence that this was once their home. Stone and copper axes, chisels, arrow-heads, and various ornamental devices that have been identified as belonging to the mound-builders are frequently found here. At Point of Rocks, about three miles south of Covington, where a high bluff of sandstone forms the eastern shore of the Wabash river, there is a "shell bank" on the summit of the bluff, extending parallel with its margin for a distance of 200 feet. Between the shell bank and margin of the bluff, the smooth sandstone is exposed from ten to fifteen feet wide. The shells are fragmentary and much decayed, but the hinges, etc., remaining, show that they chiefly belong to the Unio, now inhabiting our streams. Mixed with the shells, we found several flint tools for opening the shells and two broken arrow-heads.

In quarrying rock at this place lately, it became necessary to remove a part of the shell bank. This exposed several skeletons of adult size. They appeared to be very ancient, as they crumbled to lime on exposure to the air. No pottery nor other household implements were found, nor, indeed, could we learn that any search for such had been made.

In grading a road half a mile south of Veedersburg, the present season, nine full grown human skeletons were found about four feet below the surface. With them was found several flint arrow-heads, and a chisel of very hard and well-polished trachyte, or green stone. The bones were much decayed, and evidently belonged to a pre-historic race.

ACKNOWLEDGMENTS.

We take pleasure in acknowledging the favors we received in prosecuting our labors from the Indiana, Bloomington & Western, and the Chicago Block Coal Railroads, and from the newspapers at Attica, Covington and Veedersburg. Also our obligations to numerous private individuals who kindly assisted us by acting as guides to interesting localities, by furnishing us important information, or by extending to us their liberal hospitality.

GEOLOGY OF DELAWARE COUNTY.

PROF. JOHN COLLETT,

State Geologist of Indiana:

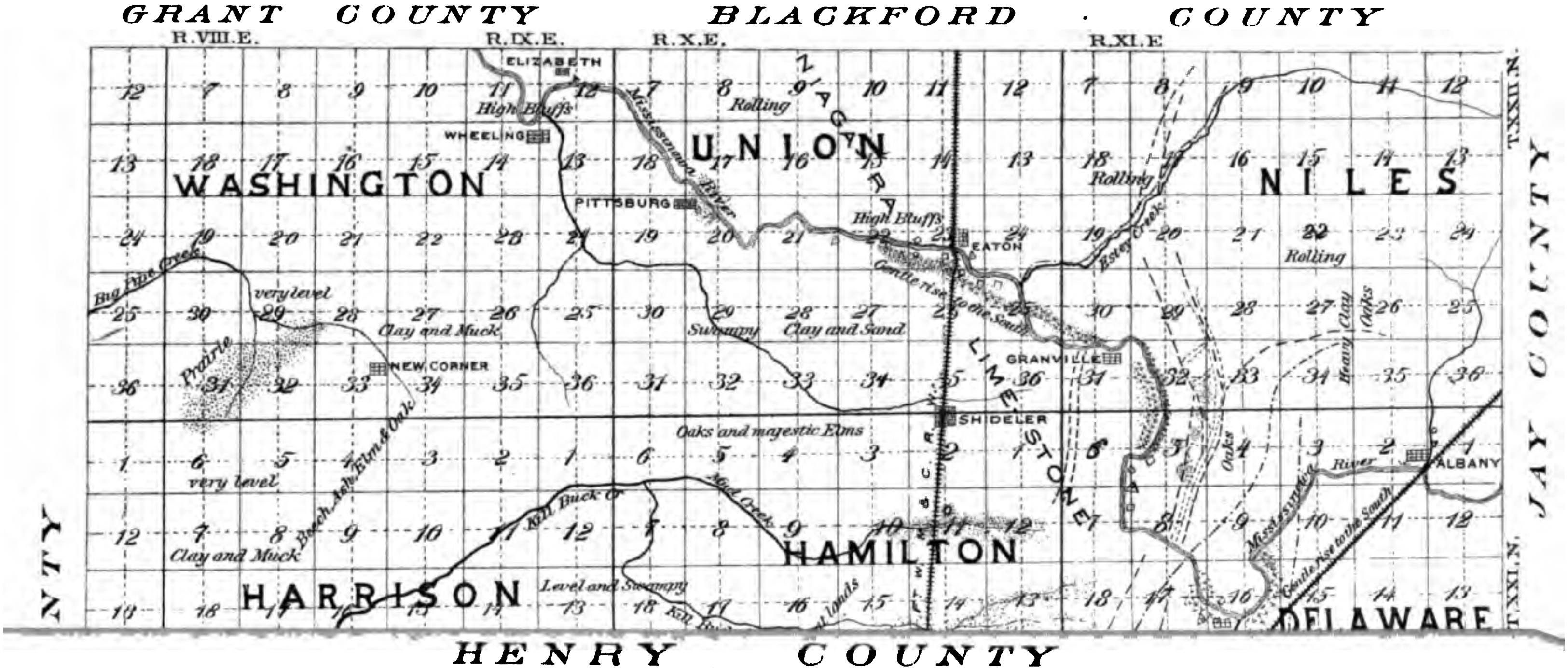
DEAR SIR—In compliance with your lettter of instructions of June 9, 1881, I proceeded to make a geological survey of Delaware county, and herewith respectfully submit my report on the same. Thanking you for valuable assistance and many courtesies, I remain, yours truly,
A. J. PHINNEY, M. D.

MUNCIE, IND., August 4, 1881.

Delaware county is situated northeast of Indianapolis, and Muncie, its county seat, is fifty-four miles from that city, *via* the Bee Line R. R.

It contains 250,104 acres, and is bounded on the north by Grant and Blackford, south by Henry, east by Jay and Randolph, and west by Madison county. It is crossed by the Cleveland, Columbus, Cincinnati & Indianapolis R. R., which enters the county at a point directly east from Muncie. Leaving Muncie, it changes its course to the southwest, and passes out of the county near its southern boundary. The Ft. Wayne, Muncie & Cincinnati R. R. crosses through its center from north to south, while the Lake Erie & Western R. R. enters it near the southern line of Harrison township, going in a direct line to Muncie, where it changes its course to the northwest, passing out of the county a little north of where the Mississinewa river enters it. The Mississinewa river drains the northeastern part; the Kill Buck and Big Pipe creeks the northwestern, while White river and its tributaries drains the central and western areas. White river, the largest of the streams, although somewhat circuitous in its course, passes through it from east to west. Its principal tributaries from the north are Mud, Hog and Muncie creeks; from the south Prairie and Buck creeks. Nearly all the smaller streams in the county have their source in the prairies, but fed in their course by numerous springs,

Map of DELAWARE COUNTY. REPORT OF JOHN COLLETT, STATE GEOLOGIST, 1881. By A. J. PHINNEY, M. D.



EXPLANATIONS:

- ▫ Limestone outcrop.
- ⊔ Limestone quarry worked.
- ⁙ Boulders.
- ⁘ Swamp.
- ∘ Spring.
- ------ Glacial ridges.
- ------ Glacial valleys.
- ▲ Mill.
- ∧ Limekiln.
- ⁴ Brick and Tile kilns.
- ✿ Indian mounds

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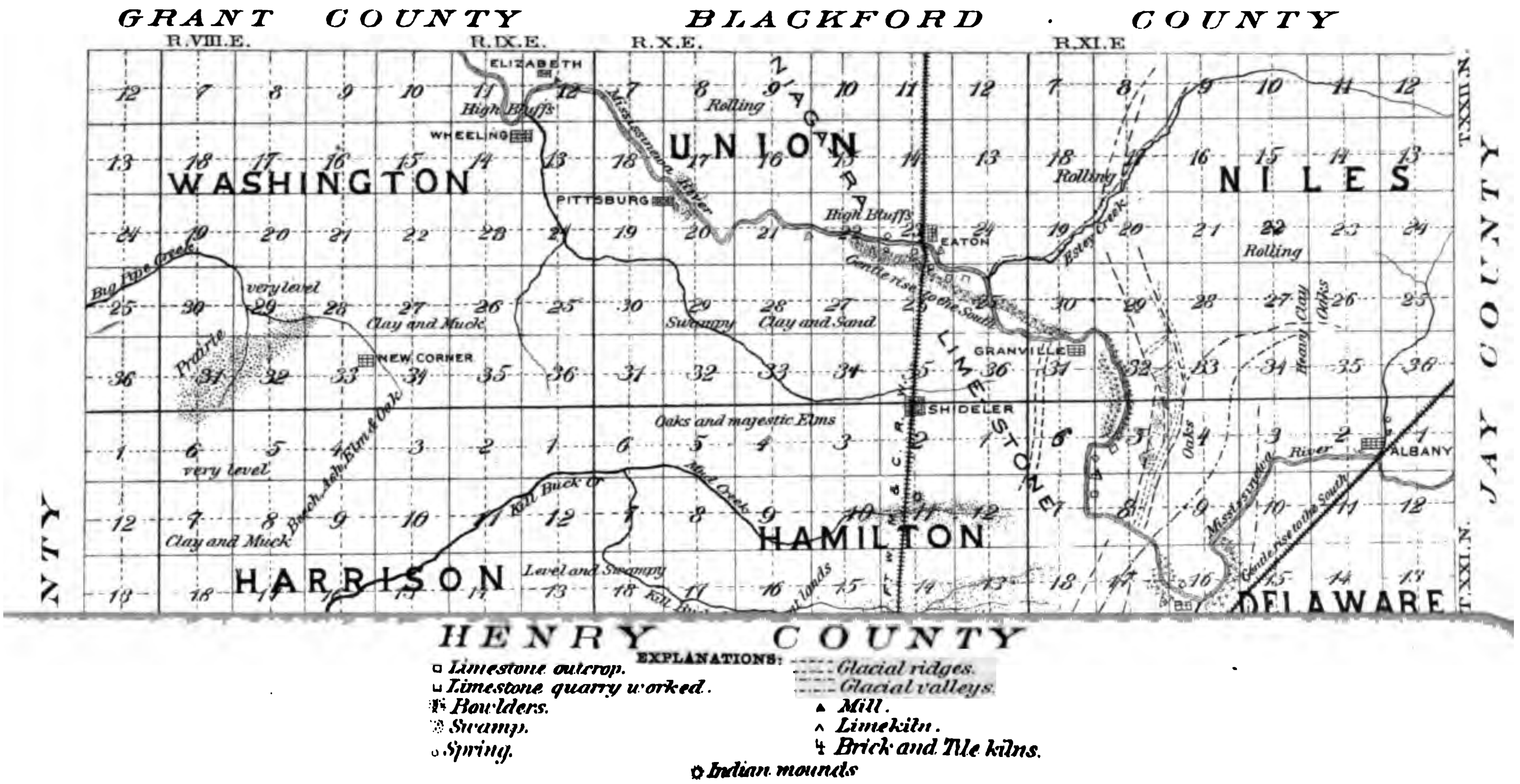
Delaware county is situated northeast of Indianapolis, and Muncie, its county seat, is fifty-four miles from that city, *via* the Bee Line R. R.

It contains 250,104 acres, and is bounded on the north by Grant and Blackford, south by Henry, east by Jay and Randolph, and west by Madison county. It is crossed by the Cleveland, Columbus, Cincinnati & Indianapolis R. R., which enters the county at a point directly east from Muncie. Leaving Muncie, it changes its course to the southwest, and passes out of the county near its southern boundary. The Ft. Wayne, Muncie & Cincinnati R. R. crosses through its center from north to south, while the Lake Erie & Western R. R. enters it near the southern line of Harrison township, going in a direct line to Muncie, where it changes its course to the northwest, passing out of the county a little north of where the Mississinewa river enters it. The Mississinewa river drains the northeastern part; the Kill Buck and Big Pipe creeks the northwestern, while White river and its tributaries drains the central and western areas. White river, the largest of the streams, although somewhat circuitous in its course, passes through it from east to west. Its principal tributaries from the north are Mud, Hog and Muncie creeks; from the south Prairie and Buck creeks. Nearly all the smaller streams in the county have their source in the prairies, but fed in their course by numerous springs,

Map of DELAWARE COUNTY. REPORT OF JOHN COLLETT, STATE GEOLOGIST, 1881. By A. J. PHINNEY, M. D.



they become clear and sparkling, a blessing to man and beast. The Mississinewa and White rivers both furnish an abundance of water for mechanical purposes. Portions of the county, that are not watered by some of the many small streams, are easily supplied by digging, water being reached at an average depth of about twenty-five feet.

The principal towns are Muncie, Yorktown, Daleville, Eaton, Selma, Albany, Granville, New Burlington, Wheeling, New Corner, Royerton and Shideler; all but the first small, not having over 350 inhabitants. Some, however, indicate considerable thrift and growth, while others show that they were once possessed with a spirit of enterprise that deserved a better fate. Muncie, the county seat and the principal commercial center, is a thrifty, growing city, with a population of 5230. It is situated on the south bank of White river. The streets, graded and graveled, are well shaded with native trees. The dwellings and business houses are neat and substantial, while many of its numerous manufactories have proven a source of great profit to their owners.

The surface of the county is generally level or gently undulating, though there are, beginning in the western part of Niles township and extending south into Henry county a series of hills and ridges; higher in the northern part and enclosing basins without visible outlet. The surface is somewhat broken along the streams. Delaware county is evidently included in the gentle fold or ridge that extends from northeastern Ohio in a southwesterly direction into Indiana, its highest point being near Bellefontaine, Logan county, Ohio, where its altitude is 1548 feet above the ocean. One of the high points in this State is in the same line or fold, eight miles southeast of Winchester, the source of White and White Water rivers, and is 1253 feet above the ocean. The summit of this ridge, in passing to the south, would be found south of the Henry county line. Delaware county then forms part of the northern slope of the divide. The Mississinewa river has its source on the northern slope of the divide in Dark county, Ohio, while the White river arises from the summit, the highest land in the State. By reference to a table of altitudes appended, it will be seen that there is a gradual rise from the Mississinewa river to near New Castle, and a gradual descent from that point south.

This county, together with those lying to the south and east, is also included in a much older fold known as the Cincinnati arch, which extends from the south line of Tennessee, with a direction a little east of north, through Nashville and Cincinnati to Lake Erie, the elevation of this part of the State taking place at the close of the Silurian age.

Topographically the county has no marked features to indicate that it belongs to either of these folds, only a gentle slope to the west, broken here and there by a series of low ridges and hills, which give variety to an otherwise monotonous surface.

As this county lies near the summit of the water-shed we do not find here that system of deeply excavated river channels found in the southern part of the State. Only four examples have been discovered, viz: Beginning in the southeastern part of Perry township and extending in a northeasterly direction, following the valleys of Prairie and Mud creeks, it terminates in the level tract north of Selma, beyond which it could not be traced. The next in importance arises in the same level tract, which extends to Albany, and crosses the Mississinewa river and the ridges about one mile northwest of Sharon; from this point it extends in a southwesterly direction, following the course of Muncie creek to White river, north of Muncie.

Mud creek and the York Prairie ditch now occupy a channel that once served to discharge the surplus waters of White river, while Estley creek now flows through a valley formerly occupied by a larger stream.

TABLE OF ALTITUDES, DELAWARE COUNTY.

Cincinnati, Richmond & Fort Wayne Railroad.

	Above Ocean.
Mississinewa river at Ridgeville, Randolph county......	964
Sum. bet. Mississinewa and White rivers, Randolph county..	1,095
Low water White river near Winchester, Randolph county..	1,053
Summit between White river and Green's fork of White Water..	1,188
Summit between Green's fork and Noland's fork of White Water, Wayne county...........................	1,212

Summit between Nowland's fork and White Water, Wayne county	1,132
Junction with Cincinnati & Chicago railroad near Richmond, Wayne county	969
Richmond City (passenger depot)	969

FT. WAYNE, MUNCIE & CINCINNATI RAILROAD.

Track on bridge over Mississinewa, Delaware county.	910
Track at Muncie station, Delaware county	948
Track at Henry county line	1,016
Track at Newcastle, on Blue river, Henry county	1,045
Track at New Lisbon, Henry county	1,109
Track at Cambridge City, Henry county	957
Track at Fayette county line	881
Surface of Lake Michigan	585
Surface of Lake Erie	573
Indianapolis Union Depot	721

GEOLOGY.

The various geological features brought together from separate localities give the following

CONNECTED SECTION.

Quarternary.	
Alluvium	10 ft.
Drift	25 to 100 ft.
Upper Silurian.	
Niagara limestone	100 ft.
Total	210 ft.

The thickness of the Niagara is estimated from a boring made some years since, near Eaton, where one hundred feet of blue limestone, similar to that found in the quarries, was passed through.

GENERAL GEOLOGY.

QUARTERNARY AGE.

These deposits, although the most recent, are among the most interesting, because they influence in a great degree all our agricultural industries. When the glaciers had retreated to the north, leaving its mass of debris behind, and the higher points of land had become dry, there remained scattered over the county many small lakes and ponds, filling the numerous depressions in the surface, and wherever to-day is found the prairie or black muck, or a swamp, there the waters remained at the close of the glacial epoch.

These depressions have, many of them, been filled up by forces still in action. The spread of vegetation with the accumulation resulting therefrom, together with the wash from the higher lands, has converted these wastes into fertile fields. In Perry township is one of the larger of these lakes, now dry, which was once evidently an ancient river channel that served to discharge the waters of the melting glacier. This is now silted up and its communication with White river nearly cut off by a low ridge of sand and gravel which was deposited by the river. Prairie creek, which now meanders through it, could never have excavated the broad, deep valley, besides, all the evidences go to show that since its connection with the river was severed, the process has been one of deposit rather than of excavation.

This was, when the county was first settled, a swamp which could be crossed only in a few places, but the spade has accomplished in a short time what would have taken nature years to do. The vegetable deposit here ranges from ten to twenty feet in thickness. The cedar timber, found along the borders of the prairie in ditching, show that the climate and vegetation has materially changed since the deposits first began. In digging wells on the adjoining high lands at a depth of about forty feet (near the level of the prairie) a layer of vegetable material has been found, composed of stumps and trunks of trees, twigs, leaves and vegetable mould. This corresponds to the forest bed of Prof. J. S. Newberry (Ohio Geological Survey) and indicates that during the glacial epoch the arctic coldness had subsided and the lands adjoining this ancient valley had become covered with forests which were destroyed and buried by the succeeding drift deposits. If this vegetation was the result of the destruction of the forests existing previous to the glacial epoch we should expect to find it near the base of such deposits, whereas, forty feet is, in our opinion, above the middle of the drift deposits in this locality. One mile west of Selma, Liberty township, is another of these lakes or peat bogs, now partially filled up, which, with the drainage, has converted the waste into wheat and corn land. When the Bee Line railroad first built their embankment across this, they returned one morning to find the result of their labors swallowed up in the depths of the treacherous bog, the accumulated mass of vegetation which had been strong enough to sustain for a time the heavy weight, had given away, precipitating the mass into the waters beneath. This point required constant watching and repair for years. No borings have been made by which the depth could be ascertained. Nearly all the small streams of the country have their source in, and are bounded throughout the greater part of their course by prairies. This is most noticeable in Harrison, Washington, Salem and Mt. Pleasant townships, where we found many of considerable size.

ALLUVIUM.

The Mississinewa and White rivers are bordered throughout the greater part of their course by broad and fertil plains, in many places showing the first and second bottoms or terraces. The material forming the bottoms is derived from the adjoining banks, enriched by the wear of pebbles and sand with the finer material brought by every creek and rivulet, is deposited during the overflow upon the flood plains of the stream. As the streams deepen their channel and shift from side to side of the valley new flood plains are formed. In many places the third bottom could be distinguished. These deposits, rich in mineral plant-food, and containing an abundance of organic material are among the best farming lands in the State.

The Mastodon.

Remains of this animal have been found in different parts of the county. No doubt the swamps and lakes, once so numerous, have served as a burial place for many who mired in their treacherous depths. Mr. Edward Tuhey found in 1878 the tooth of one on the farm of Edward McKinley, four and a half miles west of Muncie. It measured 4 by 5½ inches across the face, 14 inches in circumference, and 7 inches in depth. Dr. G. W. Kemper has the foot bone of one which was found in the eastern part of the county, the exact locality could not be ascertained. About three miles south of Muncie, on the farm of P. Carmichael, parts of a skeleton, the ribs and some of the larger bones were found, all in an advanced stage of decay.

THE DRIFT.

This deposit covers all the county, and to it we are indebted for our present physical features, as well as for soils of unrivaled fertility. After the close of the Silurian Age, the elevation of the Cincinnati Arch had carried this portion of Indiana above the ocean. At least, if any other formation was deposited here no trace of it remains. From this time until the deposit now under consideration took place, this part of Indiana was dry land, during which the Devonian, Carboniferous, Triassic, Jurassic, Cretaceous and Tertiary formations were deposited. Through the many millions of years which thus intervened, the surface was constantly exposed to the action of the elements. Deep channels must have been cut by its streams, and the surface, instead of being gently rolling as now, must have been rough and hilly, and the soils, derived from the disintegration of a limestone rock, a thin calcareous clay.

Previous to the Glacial Epoch a gradual elevation had taken place until the continent stood several hundred feet higher than at present. This was followed by a climate of Arctic coldness, during which glaciers advancing from the north, and carrying beneath them great numbers of azoic rocks derived from the Canadian Highlands, gradually covered that part of the continent as far south as the 40 parallel of latitude. As it passed over the surface, filling the valleys and covering the hills, plowing down the surface over which it passed, grinding the softer material beneath it, carrying in its bosom and shoving before it the result of its work, advancing and retreating with every increase and decrease of the cold, until, finally melting, it sent vast volumes of water to the Ohio, cutting broad valleys, enlarging the river channels, and depositing immense quantities of sand and gravel along its course. With every advance of the glacier, it shoved the material before it which it had left in its retreat, piling it up in hills and ridges, and the waters sorted the material, depositing the finer sand and clays in the quiet waters, and leaving the coarser material in the wake of the currents. Much of this material, however, gives evidence of having remained as the glacier left it.

Probably the most important characteristic of the drift deposits is their irregularity and variability, as it is the debris of the rocks over which the glacier passed. Much of its variability is due to the many different formations which have given their quota of material. Sand, gravel and clays succeed each other with but little regularity, either horizontally or vertically. The only part of the drift which shows any well marked stability of characteristics is the bowlder clay. This the base of the drift deposits is a tough, blue clay, containing many rounded, scratched and grooved bowlders, many of them of large size. It varies in thickness from five to fifteen feet, and is best seen along the streams. The bowlders we find scattered through the drift bear evidence of having been left, with their matrix, by the glacier where we now find them, but those distributed over the surface bear evidence of having been left or dropped by melting ice. The county must then have been covered with water, as boulders have been observed on the summit of the hills and ridges. The finer sands and clays of the surface which, together, form one continuous sheet, stretching over many of the hills and ridges, were deposited during this the closing act of the Glacial Epoch. The erratic rocks spoken of are usually found in belts, over the surface, miles in length, and usually along the streams. Though mostly composed of granites, greenstones, schists, etc., blocks of corniferous limestone are occasionally met with. One of large size and of pure whiteness was observed on the farm of Jacob Koonts, section 25, Mt. Pleasant township, which contained the characteristic fossils, *Zaphrentis gigantea*, *Atrypa reticularis* and *Cyathophyllum rugosum*.

The series of ridges and hills, aside from their economic value, are among the most interesting deposits found here. If, beginning at Eaton, we draw a line in a southwesterly direction through the county, passing a little west of Muncie, we mark their western limit, while none are found east of a line passing north and south through the centre of Niles, Delaware, Liberty and Perry townships. Although marked on the map as a single ridge, it consists of many short ones, together with the hills, and locally their direction may be from the north to the southwest or southeast, or due south. In the northern part of

Niles township we find a single, undulating ridge, which extends to Estey creek valley, here one-fourth of a mile wide. South of this stream we find a high table land, gradually sloping to the northeast and east, while towards the river the descent is more rapid. The surface here is mostly clay, from fifteen to twenty feet in thickness, which as we pass to the south becomes more sandy, and the numerous ridges and hills of sand and gravel enclose many basins without visible outlet. Many of these are of large size, an acre or more in extent, and show by the water which they contain that their bottoms are of clay. The shallower of these basins support a luxuriant growth of the Button bush, *Cephalanthus occidentalis*, Swamp dock, *Rumex verticellatus*, and the yellow Pond lily, *Nuphar advena.*

Towards Sharon the table land becomes narrowed to a single ridge, separating the river on the west from the level prairie on the east. It is here fully one hundred feet above the river. If we trace the eastern border of this high land we find it curves to the east, forming an arc of about thirty-five degrees.

Its transition to the plain below is everywhere abrupt. South of the Mississinewa river, the surface gradually slopes to the east and the ridge is here divided into two parts; the eastern part, however, gradually becomes lower and merges into the level plain farther south. The main ridge forms the western bank of the old river channel for about three miles, when, making an abrupt turn to the south, it is continued with occasional interruptions to Muncie. South of the residence of John Wilson, section 25, Hamilton township, another ridge extends in a southeasterly direction to Selma, where it turns to the south and forms the west bank of the old glacial river channel, of which the peat bog west of Selma is a part. The series here is wider than it is farther north, and highest along its eastern border, with a gradual slope to the west broken by numerous ridges and hills of sand and gravel. Its character here is that of a high table land, with the elevation constantly increasing to the southeast. Both the White and Mississinewa rivers, as can be seen from the map, make a bend to the south to find a passage through this high land. From Granville to a point one mile west of Eaton, we find along the Mississinewa river a continuous line of large boulders, from thirty to forty rods in width. The relation which they sustain to the high land, north of the river, would suggest that possibly this series of high lands might be a moraine. But as bowlders are numerous wherever the streams have reached the rock, this, with the direction of the ridges, would render it more probable that their exposure was due to fluviatile action. It is not likely that the glacier left everywhere in the county an equal amount of material. The inequality of rock surface would have much to do in determining this, as every rocky ridge would serve as a barrier to its advance. The great glacier was sufficiently large to override all the minor inequalities of the surface, filling the valleys and covering the hills; but in its retreat it had many temporary advances, governed by the variations of temperature, during which the material left in its retreat would be shoved before it and left as a ridge or table land.

Whether the hills and ridges just described were partially formed in that manner we leave for future investigations to decide. They were evidently formed ere the glacial streams began to flow, for we find that the old channels cut across them, and along this ridge are the highest lands in the county. From Selma to Albany we find a level tract bordered on the northwest, west and southwest by higher lands; from this the glacial streams seemed to flow; the larger and deeper one finding an outlet west of Selma, from whence it excavated the valleys of Mud and Prairie creeks flowing directly across what is now the present valley of White river. This old channel was evidently a deep one, as the height of the adjoining banks show; its rocky bottom has never been found. This is now partially silted up with sand and gravel. The next in importance crosses the present valley of the Mississinewa river about two miles northwest of Sharon; from this point it flowed in a southwesterly direction to Muncie, following the present valley of Muncie creek.

Muncie creek, as it turns to the east, evidently follows a channel of a branch of the stream just described. This stream was a broad and shallow one, as its west bank is low, only a few feet above the surface of the valley. The valley of the Kill Buck may have discharged part of its waters.

Estey creek follows an old channel which was cut wide and deep through the high land described. In this partially silted up valley we find the clearest evidence of fluviatile deposits seen anywhere in the county. The north bank of the creek is from ten to twelve feet high, and yields fine gravel. All the deposits here (sand, gravel, clay, and dark streaks indicating vegetable material,) showed the peculiar stratification due to currents of water. Nothing like it has been observed anywhere in the hills or ridges.

The material forming the hills and ridges, sand, gravel and clay, which border the old rivers, was in part deposited by them. The bowlders, limestones and clays, observed near the base where the old river had cut through them, evidently served as a nucleus around and over which the finer material was deposited. The conical or rounded hills or short ridges which, from their position, show that they are not connected with any of the ancient lines of drainage, probably have a different history. Two, near Muncie, which I carefully examined, and which, so far as appearances are concerned, are like all those seen, have as a nucleus a large mass of unstratified blue clay. How the mass of clay, so different from the stratified clays of the surrounding country, came there, is a difficult question to answer; unless, as we suppose, *it*, with a part of its sand and gravel, is the *debris* of the melting glacier. Similar hills are found in a belt along the summit of the divide, between the lake basin and the Ohio valley, all the way across the State of Ohio.

As a brief summary of events in the history of the drift, we have, first, a pre-glacial surface several hundred feet higher than now, deeply scored by drainage lines. Second, the advent of the ice period during which, glaciers advancing from the north ground down the underlying rocks, filled the valleys, covered the hills and melting, left vast quantities of sand, gravel and clay scattered over the surface. Third, a retreat of the glacier followed by a milder climate during which parts of the surface had again become covered with forests. Fourth, a submergence during which the surface clays were deposited and floating ice were scattering their contents over the country. Fifth, a gradual but unequal elevation, a retreat of the waters and the establishment of the present lines of drainage.

PALEOZOIC GEOLOGY.

The rocks exposed in this county all belong to the upper silurian age, and are known as the Niagara limestone. This rock, wherever exposed, is highly magnesian, very friable and refractory. The upper layers are usually cherty and worthless; some of the strata are silicious, and all contain more or less iron.

The exposures occur only on the White and Mississinewa rivers. On the former only two outcrops are seen, viz: at Union and Yorktown, and are the result of the river cutting across narrow ridges. Exposures occur at intervals on the Mississinewa throughout its course. The river evidently does not follow its old channel; but flows through part of its course south of a series of ridges.

At the quarry of L. D. Koontz, near Yorktown, we obtained the following:

Section at Yorktown.

1.	Boulder drift	4 ft.	0 in.
2.	Drab argillaceous limestones in layers from one to three inches	4 ft.	9 in.
3.	Bluish limestone argillaceous in layers from three to six inches	5 ft.	7 in.
4.	Bluish limestone, two layers		9 in.
5.	Blue and drab limestone, in layers from two to eight inches, silicious	5 ft.	10 in.
6.	Blue limestone, strata from six to twelve inches, below water	7 ft.	0 in.
	Total	27 ft.	11 in.

Of the above, No. 2 is worthless; No. 3 is used principally for walling wells; No. 4 is the most marked strata seam, and seems to be solid, but in working, it splits into two parts; No. 5 contains the best stone in the quarry above the water; No. 6 is the best stone, and with No. 5, is the principal stone used for foundations and walls, being very refractory, however, it allows of very little dressing. Very little of this stone is suitable for lime. The dip here seems to be to the southeast five inches to the rod, but this is undoubtedly due to false bedding. The principal fossils found here are *Orthoceras annulatum* and varieties, *Calymene blumenbachi*, *Orthoceras strix*, *Platyostoma*, etc.

Across the river and one-quarter mile above, is another quarry which differs somewhat from the above. As the section will show, the dip here was to the southwest, and all the strata were thicker in the other.

Section East of Yorktown.

1. Bowlder drift	1 ft.	0 in.
2. Argillaceous shale	4 ft.	0 in.
3. Argillaceous limestone	1 ft.	8 in.
4. Drab limestone cherty, divided into two layers, and containing nodules of iron	1 ft.	0 in.
5. Drab, limestone lower part cherty, in layers one to six inches	1 ft.	8 in.
6. Blue limestone. lowest strata exposed, works eight inches	3 ft.	8 in.
Total	12 ft.	0 in.

Here we note an absence of many of the shales from the upper part. This is due to the planing which the glaciers gave them as the numerous bowlders which are scattered to the north show that this was a ridge it could not obliterate. The lithological characters are changed somewhat as we notice a greater prevalence of the cherty layers and their occurrence in the deeper strata of the quarry.

Across the river and about forty rods above is another quarry, a section of which would correspond to the upper part of the one just given. Neither of these produce stone suitable for lime. About one-quarter mile above these stone has been found suitable for lime, as the old kilns show, but none is being burned at present. No glacial markings were seen here or at any exposure in the county, as the character of the rocks is such that they would not be retained. On White river, east of Muncie, we have exposed three feet of drab, friable limestone, and three feet of blue limestone. None of this is suitable for architectural purposes. Here we find the only fossil bed in the county. It is literally one mass of fragments of corals, crinoids and brachipods, very few however, in a good state of preservation. As an experiment, enough of this stone was taken out by blasting to pave part of Walnut street this city. It wears smooth and gives evidence of durability.

A short distance below this exposure this stone is quarried for lime. It is here of a drab color and is not so friable as the former, and makes good lime. On the north bank of White river, below Wysor & Co.'s dam, is an exposure of five feet of gray limestone. This is quite extensively quarried, and is among the best stone found in the county for lime. Mr. Kirp, the proprietor, has a perpetual burner capable of producing one hundred bushels per day. He expects this year to burn about 15,000 bushels; this little more than supplies the local demand.

Near Albany, on the creek, is an exposure of about two feet. Enough of this was quarried some years since to build the abutments of the bridge which now spans the creek. Though the strata are of good thickness, from three to ten inches, yet the stone is so rough and refractory that none has been quarried since.

Near the central part of Delaware township, at the bend in the Mississinewa river, the rock is exposed for about two miles. It is here of a yellowish red color, sometimes quite rusty, and is quarried principally for lime, very little good building stone being found here. But little more lime is burned than is needed to supply the local demand. On Campbell's creek, south of Sharon, Mr. J. A. Pettinger has opened a quarry. The rock is better than at any other exposure. It is of drab color, with occasional bluish layers. The strata range from two to eight inches in thickness. Six feet are exposed. Parts of this make good lime, but it is too friable for good walls. About twenty rods above this quarry the rock undergoes a marked change. The upper part consists of shales two feet, with a blue clay intermixed, and below, to an unknown depth, of a whitish limestone. It is here in layers from four inches to a foot; is smooth on both sides, and its lines of clearage straight, and can be easily taken out in blocks from one to two feet in width. Below what could be seen there was said to be a strata one foot in thickness, and of a white color. Considerable stone was taken from this place some years since, but, although the best stone found in the vicinity, the rock has never been properly worked. In my opinion we have here the best stone for architectural purposes to be found anywhere in the county, and, although only a local change in the character of the rock, it may be extensive enough to supply the county with stone for years. As Delaware county contains so little good building stone, it is to be hoped that some one of our quarrymen will open a quarry here rather than spend so much time and labor removing so many feet of worthless stripping to obtain a few feet of, at best, a very refractory stone, when this could be obtained with very little labor, as nearly all the stripping required would be the alluvial deposits of the creek, not exceeding three feet anywhere. The rock is exposed along the river at intervals between Sharon and Eaton. At the latter place, Mr. George W. Carter is working a superior stone, though it corresponds very closely to the rock found at Yorktown.

The following section was obtained:

Section at Carter's Quarry.

Bowlder drift	2 ft. 0 in.
Gray argillaceous shale, cherty	3 ft. 0 in.
Gray argillaceous limestone, in layers from 2 to 6 inches, silicious	2 ft. 9 in.
Blue limestone, strata 3 to 6 inches	4 ft. 2 in.
Blue limestone	1 ft. 0 in.
Blue limestone	1 ft. 0 in.
Gray limestone, below water	unknown.
Total	13 ft. 11 in.

This stone is very hard and refractory, and allows of very little dressing. None but the blue stone is suitable for lime.

The shales are heavily charged with iron, and where very argillaceous resemble burned clay. They contain masses of chert, calc spar, nodules of iron, and concretions lined with quartz. Parts of the strata showed false bedding. The dip was found to be to the southwest about four inches to the rod. Below this quarry was another, which gave the same quality of stone, and the section taken corresponds to the one just given. The principal fossils found here were *Orthoceras annulatum*, *Platyostoma*, and *Calymene blumenbachi*. Below this quarry the rock was exposed for about one and a half miles, but as the exposures correspond to the cherty layers found in the quarries it is of no economic value.

East of Wheeling, on the Mississinewa river, is an outcrop of about six feet of drab limestone, in layers from two inches to one foot in thickness, and corresponds to the uppert part of the Eaton quarry. Work has been abandoned here on account of the thickness of the overlying drift. We were unable to obtain any fossils, though species of *Othoceras* have been found here by the workmen. It will be seen from the description given that the exposures at Albany, Sharon and Muncie, correspond in lithological characteristics, while the Eaton rock corresponds to that at Yorktown.

We have evidently two rocky ridges both wider at the north and extending from the north in a south-westerly direction. East of Muncie near where the R. R. crosses the river the rock is near the surface, while in Muncie about 1 mile west of that point, wells have been sunk to a depth of 60 feet without reaching the rock. No exposures occur below Yorktown, these facts with others show that both these outcrops are due to the river not following its old channel, but cutting across this ridge exposes it to view.

List of Fossils in Delaware County.

UPPER SILURIAN AGE.

NIAGARA GROUP.

RADIATA.

POLYPI.

Alveolites indianensis	Hall.
Cystiphyllum niagarensis	Hall.
Cladapora reticulata	Hall.
Favosites niagarensis	Hall.
Favosites favosus	Hall.
Heliolites interstinctus	Linneus.
Heliolites megastoma	McCoy

ECHINODERMATA.

CRINOIDEA.

Eucalyptocrinus crassus	Hall.
Eucalyptocrinus ovatus	Troost.

MOLLUSCA

BRYOZOA.

Fenestella acmea	Hall.
Fenestella parvulipora	Hall.

BRACHIOPODA.

Atrypa recticularis	Linneus.
Pentamerus oblongus	Sowerby.
Pentamerus nysius	Hall.
Pentamerus knappi	Hall.
Rhynchonella indianensis	Hall.
Rhynchonella neglecta	Hall.
Rhynchonella stricklandi	Sowerby.
Rhynchonella cuneata	Sowerby.
Rhynchonella whitii	Hall.
Rhynchonella acinus	Hall.
Spirifera radiata	Sowerby.
Spirifera niagarensis	Hall.
Spirifera crispa	Hall.
Strophomena rhomboidalis	Wahlenburg.
Strophomena striata	Hall.
Streptorhynchus subplana	Conrad.

PTEROPODA.

Tentaculites niagarensis	Hall.

GASTEROPODA.

Platyostoma niagarensis	Hall.
Strophostylus cyclostomus	Hall.

CEPHALOPODA.

Gomphoceras septore	Hall.
Gyroceras elrodi	White.
Lituites marshi	Hall.
Orthoceras crebescens	Hall.
Orthoceras annulatum	Sowerby.
Orthoceras trix	Hall and Whitfield

CRUSTACEA.

Calymene blumenbachi, (var. *niagrensis*)	Hall.
Phacops limulurus . . . . *Sp.*	Hall.

ECONOMIC GEOLOGY.

COAL.

Next in importance to knowing what a district of country does contain, is a knowledge of what it does not contain. The question is frequently asked, have we coal in Delaware County? to this question we would reply that coal never has, and *never will be* found here as a deposit; pieces of coal have been found in the drift deposits in the northern part of the county; these evidently came from the coal fields of Michigan, brought here by the glacier. Mr. Jacob Newberger of Grant County found a few pieces in the bed of the Mississinewa River, and mistaking the dark colored bowlder clay for a coal showing, he endeavored to get some one to open a mine but without success.

Coal as a deposit is always found in certain groups of rocks; in this State the Carboniferous is characterized wherever found by the fossils which it contains, and the Carboniferous rocks of this State are only found in the south-western part; the rock which underlies this county, the Niagara Limestone, is many hundreds of feet below the true coal bearing rocks. A knowledge of this fact would have saved many hundreds of dollars to the parties who made a boring at Eaton some years since, with the expectation of finding coal or oil.

LIME.

Lime of an excellent quality is burned here, principally to supply the local demand. This industry might be increased so as to become a source of great profit as the rock about Muncie is easily obtained, and is convenient to a shipping point.

MINERAL SPRINGS.

These springs are quite numerous. The most notable ones are the "Inlow Springs," four miles southeast of Muncie, on White River. Here are two large springs which issue from the top of the boulder clay; one of these springs is heavily charged with iron and sulphur, as shown by the deposits around it. Both, however, are chalybeate, and possess tonic and alterative properties. Numerous springs of like character were observed throughout the county. The water from the wells is hard, owing to the presence of lime and magnesia. I have failed to find either a well or spring of soft water in the county.

CLAYS.

Good clay for the manufacture of bricks can be had in abundance in every township, and is easily obtained, as the surface clays are among the best found in the county. Numerous kilns, both for brick and tile were observed; the principal ones, however, are found near Muncie. Mr. E. P. Smith burns annually about 1,000,000 bricks, and 200,000 feet of tile. Mr. Jos. Pretzman, whose kiln is located one mile south of the city, manufactures annually about 1,000,000 bricks; last year he made 1,500,000. All the bricks and tiles manufactured here have been used in the county. This indicates the improvement of both the city and county.

GRAVEL AND SAND FOR ROADS.

Gravel from the drifts is easily obtained, and forms both the cheapest and best material for roads. Many good pikes are already constructed, and each year additions are made to these important highways. All the roads leading to Muncie, but one, are pikes thus connected with the surrounding country, Muncie enjoyes commercial advantages excelled by few cities of its size.

EDUCATION.

The common schools are the pride of the people, for it is there that the masses obtain that which enables them to grapple successfully with the stern realities of life. School houses are found in every part of the county, and the old frame ones are fast being replaced with brick buildings of a more modern style. Each year a Normal School is held in Muncie, the purpose of which is to instruct and inspire the teachers with that which will enable them the more efficiently to perform their duties. The Muncie High School building ranks among the finest in the State, and the patrons of our public schools refer with pride to their efficiency.

AGRICULTURE.

The soils are all derived either from the lacustral, alluvial or drift deposits. Those of the latter are mostly clays, with the exception of occasional sandy or loamy tracts, and constitute the greatest part, being the debris from different formations indiscriminately mixed, we have all the elements present which constitute mineral plant food. This mixed with the vegetable accumulations give a soil capable of producing crops of all kinds. Wheat, corn and flax, however, are the principal dependence of the farmer. The number of acres of wheat sown in 1879 was 32,295; corn, 37,137; flax, 9,943. The soils, although especially adapted for wheat and corn, produce grass of an excellent quality, and grazing will some day be one of the chief resources of the county. East of the series of ridges, the soil is a heavy clay, with tracts of muck, and is not so well adapted to grain as it is to grass. Along the ridges the soil is sandy or loamy in places, and is among the best wheat and corn lands in the county. While the western part is clay, we find here numerous lacustral deposits, which makes this the richest and most productive soil, and though the last to be settled, it is being rapidly improved, and within a few years the finest farms of the county will be found here. A more general use of tile, with sufficient ditching, would render fertile many swampy tracts, improve the clay soils and be conducive to the health of the people. In fact, all the soils would be benefited by proper underdraining, as it renders the heavy clays lighter and more productive. The lacustral deposits or peat bogs and muck, which constitute about one-twentieth of the surface, and capable of producing almost without limit, ought, we believe, to serve as a fertilizer. The clay soils are constantly losing their organic material, and unless supplied from some source, will soon become stiff and unproductive.

While proper underdraining will render them lighter and enable the crops to send their roots deeper, the constant loss of vegetable and mineral plant food, with every crop harvested, will in time render this soil unproductive. No rotation of crops will have a tendency to improve the fertility of the soil; for, although corn, wheat, flax and grass may succeed each other with profit, as the proportion of mineral material required by each is different, yet the constant loss is greater than the gain. As every crop taken from the field withdraws some of the potash, phosphates, lime and other plant food, it must not be supposed that the same soil will continue to yield, even with the most skillful rotation, undiminished crops. The question then arises, how can we best maintain the fertility of the soils? The vegetable and in part the mineral material can be supplied by turning under crops of green clover, straw, and weeds which become abundant as the soil deteriorates; this with a judicious top-dressing with barn-yard manure, with lime and the ashes and bones found on every farm, would soon place our soils in condition to produce from one-half more to twice their present amount. After a few years the plow might be put still deeper, thus bringing into use those resources which have been lying idle. The peat and muck is abundant and is easily obtained, and if properly distributed over the adjoining clays, would be of greater profit to the farmer than their productions as wheat or corn fields. This deposit, although rich in vegetable material, is markedly deficient in the mineral ingredients which constitute a good soil, and it will be necessary to use the mineral fertilizers if we wish to maintain their present fertility. To protect the larger of these deposits from fire, we would suggest that the drains be closed during part of the year, thus allowing the lower portion to become saturated with water, for if dried to any great depth, fires would be hard to extinguish and very destructive.

The native grass (*Poa pratensis*) blue grass, grows here in abundance, and of excellent quality. Timothy (*Phleum pratense*) and clover (*Trifolium pratense and repens*), succeed as well here as in any part of the country. We frequently saw fields of clover and timothy that would yield from two and a half to three tons per acre. This adaptation of our soils to the grasses would render dairying a very profitable industry.

LIVE STOCK.

This department of husbandry is capable of being much increased; the abundance and excellent quality of the native grasses with corn in abundance, will produce as fine beef as can be found any where, as the magnificent Durhams show. Good swine are raised in abundance, and are a source of great profit to the farmers. Large numbers of heavy draft horses are annually shipped to the cities. Few counties will be found in the State which are capable of supporting a greater variety of industries.

FRUITS.

Apples and the cultivated small fruits are raised here in abundance. The extreme cold last winter destroyed about one-third of the apple trees, and injured many others so that the crop will be limited for a number of years to come. Raspberries and blackberries, which are found wild in many places, are scarce here. The wild plum, however, is quite common.

The sandy ridges and hills produce the finest orchards seen, and a more general use of them for fruit growing would be profitable. Grapes could be easily raised, and would ripen early. These ridges will be when developed, the finest fruit lands in the county.

TIMBER.

The county was originally heavily timbered with oak, hickory, maple, beech, elm, ash and black walnut, and as there has been but little of that reckless waste of timber, which has characterized many counties, we still have a plenty of this valuable material. Immense number of staves are annually required to supply the factories here, and large quantities are shipped away every year. This would be a desirable location for manufactories of all kinds, which work principally in wood. The eastern part of the county is timbered principally with the different kinds of oak and hickory; the central, with oak, maple, hickory and ash, while the western part produces majestic elms, beech and ash. The following were the more common and important of the trees observed.

Acer saccharinum	Sugar maple.
Acer sacharinum var. *nigrum*	Black maple.
Acer dasycarpum	Silver maple.
Acer rubrum	Swamp maple.
Quercus rubra	Red oak.
Quercus alba	White oak.
Quercus tinctoria	Black oak.
Quercus macrocarpa	Bur oak.
Quercus imbricaria	Jack oak.
Quercus palustris	Pin oak.
Æsculus glabra	Buckeye.
Æsculus flava	Sweet buckeye.
Nyssa multiflora	Sour gum.
Liriodendron tulipifera	Poplar.
Sassafras officinalis	Sassafras.
Celtis occidentalis	Hackberry.
Ulmus americana	Water elm.
Ulmus fulva	Red elm.
Negundo aceroides	Box elder.
Cercis canadensis	Redbud.
Ostrya virginica	Ironwood.
Fagus ferruginea	Beech.
Prunus americanus	Red plum.
Prunus serotina	Black cherry.

Prunus pennsylvanica	**Red cherry.**
Juglans nigra	**Black Walnut.**
Juglans cinerea	**Butternut.**
Fraxinus americana	**White ash.**
Fraxinus sambucifolia	**Black ash.**
Cornus florida	**Dogwood.**
Cornus paniculata	**Cornell.**
Cornus sericea	**Kinnikinik.**
Carya alba	**Hickory.**
Carya amara	**Pignut.**
Platanus occidentalis	**Sycamore.**
Gleditschia triacanthus	**Locust.**
Carpinus americanus	**Blue beech.**
Cratægus tomentosa var. *mollis*	**Thorn.**
Tilia americana	**Basswood.**
Tilia europoea	**Basswood.**
Populus alba	**Poplar.**
Populus angulata	**Poplar.**
Populus monilifera	**Poplar.**
Populus candicans	**Balm of Gilead.**
Populus tremuloides	**Quaking Asp.**
Salix nigra	**Black Willow.**
Salix sericea	**Swamp Willow.**
Salix petiolaris	**Swamp Willow.**
Catalpa bignonioides	**Catalpa.**
Morus nigra	**Black Mulberry.**
Morus rubra	**Red Mulberry.**

ANTIQUITIES.

Although no such extensive works of that pre-historic race, the "Mound Builders," are found here as are observed in Randolph, Henry and Madison Counties, yet we have evidence that this was also once their home, many of their implements are found in the southern and central parts of the county; these consist principaly of axes, pestles, arrow-heads, hammers, pipes with occasionally articles of ornamentation, although many have been found they have all been gathered up by collectors or lost, and we were able to obtain only a few.

A number of mounds were found along the rivers; these were all small about twenty feet in diameter and four feet high and were sepulchral, as bones in an advanced stage of decay with ashes and charcoal have been found in those which have been opened. Around one near Yorktown stones were observed which showed the action of fire. In section 2 Perry township was an enclosure, now obliterated, this was situated upon the summit of a natural hill and commanded a good view of the surrounding country; the enclosure was 130 feet in diameter, circular, with a ditch inside which, when discovered, was about ten inches deep. In the center was a small mound from which a passage way led in a south-westerly direction through the enclosure, numerous implements were picked up here when first discovered. The Indians used many of the hills as burial places; bones have been discovered which from their size would indicate that they belonged to a race of giants. In Monroe township, section 35, are four hills of sand and gravel which are described, by Kinghman Brothers in their history of Delaware County, as being the work of the Mound Builders; these are all natural hills and were formed by currents of water.

THANKS.

Acknowledgments are due to the citizens generally. Thanks are especially given to Rev. D. S. McCaslin, for his valuable assistance, to Dr. S. V. Jump, for specimens and information, Dr. G. W. Kemper, J. L. Little, John Cecil, A. H. Kennedy, L. D. Koonts, Jacob Koonts, Geo. W. Carter, A. J. Pettinger, O. J. Lotz, J. F. Nickey, and especially to Geo. K. Greene of New Albany, for indentification of fossils, and to the citizens of the county generally.

GEOLOGY OF BARTHOLOMEW COUNTY.

By Moses N. Elrod, M. D.

PROF. JOHN COLLETT, A. M., *State Geologist:*

DEAR SIR:—I herewith submit a Report of a Geological Survey of Bartholomew County.

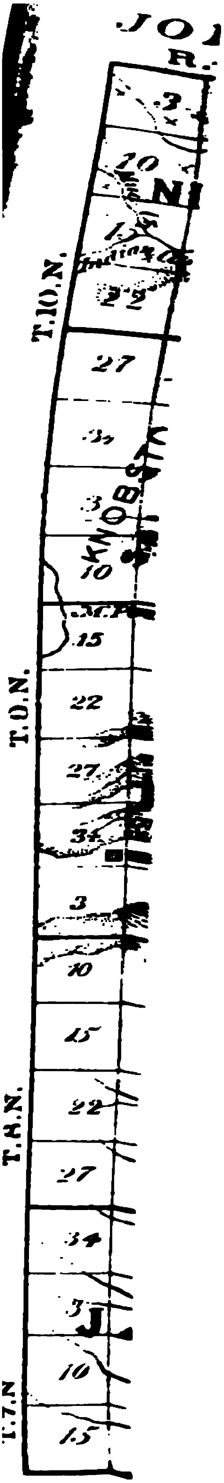
Thanking you for valuable aid, many courtesies and suggestions as to the Geology of the drift period, I am, very respectfully,

MOSES N. ELROD, M. D.

Hartsville, Ind., September 4, 1881.

Columbus, the county seat of Bartholomew county, situated near the center of the county, is forty-one miles east of south of Indianapolis, on the main line of the Jeffersonville, Madison & Indianapolis Railroad. The county comprises an area of about four hundred square miles, two hundred and fifty-six thousand acres. In the early history of the State it formed a part of Delaware county, and was organized as Bartholomew county under an act of the Legislature, approved January 9, 1821. Originally it included most of the territory now embraced in the county of Brown. Johnson and Shelby counties bound it on the north, Decatur and Jennings on the east, Jennings and Jackson on the south, and Jackson and Brown on the west.

In addition to the main line of the Jeffersonville, Madison & Indianapolis road, the Madison and Cambridge branches center at Columbus. By these north and south roads the business of the central part of the county is well accommodated with transportation, and from present indications the wants of the other sections will soon be met by the building of a road from Columbus to Greensburg, over some one of the proposed routes.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Columbus is a city of over 5,000 inhabitants, and one of the most active, pushing, business places in the State. It is beautifully located on the west bank of White river, at the foot of the famous "Hawpatch" region; is equipped with a full city government, well supplied with water works and gas, and withal healthful, and has a bright prospect for the future. Jonesville, Walesboro, Taylorsville, St. Louis Crossing, Clifford and Elizabethtown, are all thriving railroad towns. Hope is the first and Hartsville the second largest towns in the county. Azalia, Burnsville, Waymansville and Bethany are prosperous villages.

TOPOGRAPHY.

The monotony of an otherwise generally level country is diversified by many a hill and valley in the west part of the county, especially that portion of the county lying west of Columbus, forming the western parts of Ohio, Harrison and Union townships, and locally known as the "Brown county edge of Bartholomew."

An eastern continuation of the central ridge of the Brown county knobstone enters the county at the southwest corner of Harrison township, and reaches its greatest altitude at Taylor hill, in Sec. 36, T. 8, N. R. 4, E. Taylor hill, the highest point in the county, is 1,003 feet above tide level, and 360 feet above Columbus. From its summit magnificent views of the surrounding country may be had. On a clear day when the air is pure the unaided eye can trace for miles, as a blue line against the horizon, the eastern boundary of the great Driftwood-White river valley. The observer may see Georgetown to the northwest in Brown county, Edinburg in Johnson county, and Columbus and Walesboro in Bartholomew. From Taylor hill the Wall ridge, as Prof. Collett has named it, trends to the north through Union township, thence west through Nineveh township to the Brown county line. It is not a continuous ridge, but a series of high points intersected by numerous valleys and gaps, that fall away to the lower lands of the east and west, north and south. The central and northern parts of Nineveh township, while broken by outliers and foot-hills of the Wall ridge, are generally what may be termed rolling lands. Low hills and ridges, ranging from twenty-five to fifty feet in height, occupy much of the country between the knobstone summit and the bottoms of Driftwood, White river, and to the south of the ridge in Ohio and Jackson townships. The central portion of the county is level, much of it below and in the vicinity of Columbus being White river bottoms, ranging three to four miles wide. North of the county seat sets in the Haw-patch plateau, extending from White river to the Shelby county line, renowned as an extensive tract of arable land, level and fertile as any prairie, primevally covered with a magnificent forest of great trees, devoid of undergrowth.

The eastern parts of the county are usually rolling, and some parts spoken of as hilly, but the application of the term hill, *i. e.*—an elevated mass of land—is a misnomer. The so-called hills are not elevations above the level of the country, but valleys cut from twenty to seventy feet below the general surface. This distinction is important, as will further appear when we come to discuss the geology of the drift period. Especially are the valleys marked in the vicinity of Hartsville, and in the northeast part of Clifty township, on Fall Fork and Middle Fork creeks.

DRAINAGE.

What is given as the east fork of White river on the State and school maps, is locally, and it is claimed, correctly known as Driftwood from Edinburg down to the mouth of Flat Rock creek, from that point south as White river; but as the term "Driftwood" is indiscriminately applied to any portion of the river in the vicinity of Columbus, and is not used generally outside of the county, we shall drop the name Driftwood and use the name White or East White for all parts of the east fork of White river below Edinburg. Above Edinburg the same misapplication of terms recurs in calling East White river Blue river.

White river crosses the northern boundary of the county near Edinburg, and bears thence in a general course east of south through the central part of the county. From Edinburg the river follows and runs through the foot hills of the wall ridge of Knobstone till it reaches the sand and gravel bottoms below the mouth of Catharine's creek. Above this the river flows through a stony bed of black shale, and is not subject to great overflows; below the banks are low, the bed gravelly, shifting and frequently overflown. According to the table of altitudes of the main line of the J., M. I. railroad, the bed of the stream, Blue river, is fifty-three feet higher at Edinburg than the bed of White river at the Columbus bridge. From the same tables we find the fall in the river from Columbus to the Rockford bridge to be thirty feet, showing that the fall per mile is 100 per cent. more above than below the city. Advantage has been taken of this fall and utilized to run the extensive flouring mills at Lowell and the Valley Mills west of Taylorsville. The permanent banks and swift current of the upper river invite further investments in manufactories. Messrs. Stansberry and Williams give the mouth of Flat Rock creek at 602 feet above the level of the ocean, and that of Clifty creek at 596 feet above, making the fall six feet in five miles as compared with a fall of fifty-three feet in fifteen miles of the river above the mouth of Flat Rock. The fall in the Ohio and Mississippi rivers from Louisville to the Gulf of Mexico is less than four inches to the mile. The difference between high and low water at Columbus is given at fifteen feet.

A few rivulets and brooks that rise west of the Wall ridge flow into an arm of Salt creek that cuts the northwest corner of Harrison township, and finally unites with East White river below Bedford, in Lawrence county. With this exception all the streams of Bartholomew county empty into White river within the county or soon after it enters Jackson county. The general course of the creeks is east and west, with the surface of the country, and to the south of the center of the greatest depression of the White river valley. White creek, and its tributaries, leave the county in a more southern direction, and unites with White river below Seymour. The creeks of the west side of the river, beginning in the northwest, are Big Nineveh creek, Muddy branch, Catharine's creek, Wolf creek, Denois creek, and White creek and its tributary the East Fork of White creek; on the east are Flat Rock river, Haw creek, Clifty creek and Little Sand creek and their tributaries, Little Haw creek, Fall Fork, Middle Fork, Otter creek, Brush creek and Bear creek, together with other small streams, named and not named on the map. The banks of the creeks on the west side of the valley, after reaching the low lands, are cut in the clay and mud without proper first or second bottoms, in appearance very much like artificial ditches, and hence overflows are common. The creeks flowing through the Hawpatch have low banks in the gravel with well marked second banks. Those of the limestone region of the east are deep and rocky, and the present beds are never filled by rain storms to their full carrying capacity.

GENERAL GEOLOGY.

QUATERNARY AGE.

Recent and Drift Periods.

The recent and drift periods, aside from the inquiries aroused in the mind of the most casual observer of nature, as to the origin of the soil, clay, sand, gravel and bowlders that go to make up these periods of mixed materials, out of which order comes, when closely studied, are the most interesting from a practical point of view as the base of all agriculture, the source of all wealth.

MATERIALS OF THE DRIFT PERIOD.

In order to a proper understanding of the wonderful forces that came into play during the glacial and terrace epochs of the drift period, we will first consider the clays, sands, gravels and bowlders that go to make up the mass of these groups, and their distribution over the surface of the stratified rocks, and then discuss the theory and dynamics of their origin. In general terms we may say that the whole of the surface of the county is covered with drift materials, except the top of the wall ridge, and the hills to the west of it in Harrison and Union townships, and doubtless these high hills have been subjected to the action and influences of the waters of the terrace epoch, that have so greatly modified and rearranged the ancient glacier deposit.

The upland gravel beds are collections of pure sand, clean gravel and small bowlders, found only on the high grounds and ridges, that I believe to be identical "hog's-backs" of the Ohio survey, and the *kames* and *eskers* of the authors; especially are these beds of gravel identical in only being found on the high lands, and in being much less modified and rearranged by the action of water subsequent to the glacial epoch. In stratification the beds are very irregular and seldom conformable one with another; more frequently no indications of stratification are seen, the beds when opened showing sand at one end and coarse gravel at the other; the strata frequently interlock and alternate in cross sections without reference to the underlying beds. This want of uniformity of stratification is in marked contrast with that of the low land gravel as seen in the Hawpatch. The town of Hartsville is built on a rolling elevation, ranging from forty to fifty feet above the valleys and facing to the southwest. It is bounded on the west by the deep bed of Clifty creek, and on the south by the gorge, through which flows Boner's branch. In the south part of town, capping the bluff that forms the north bank of the Boner's branch gorge, there is a typical bed of upland gravel. It has a steep, rounded head at the east end, on which the Hartsville University building stands, and trends thence west in a low ridge that slopes to the north, terminating in an abrupt bluff at the west, with a spur to the south. The high bluff west of Jackson street is also capped with gravel that, in an irregular way, is connected with the bed found in the University campus. The gravel beds that occur on the farm of William J. Herron, near the Tarr hole of Clifty creek, and that on the farm of R. B. Kent, near Hartsville, are very similar in structure to the one above described, and are all peculiar in presenting on one side at least, a very bold, abrupt face. The upland gravel found on the farm of Mrs. Amy Wiley, west of Anderson's Falls, in Clifty township, is another extensive bed that, like the preceding examples, seem to be in some way connected with the drainage of the country at the close of the drift period. The occurrence of these beds on the immediate bluff banks of streams, now small, it is true, but once great, is not accidental. In thickness they range from ten to twenty-five feet, but seldom reaching the last figure. Whenever cut through to the bottom, it has been found to rest directly on the underlying corniferous limestone. Nowhere has it been found mixed with any but the surface clays, and in these instances the mixing seems to have been accidental. Near the surface masses of cemented gravel, conglomerate are not infrequent, in which the cementing element, or matrix, is carbonate of lime, deposited by the hard waters that percolate from above through a calcareous soil. Other beds of upland gravel are those on the farm of Mrs. E. Jones, near the Haw Creek Baptist church; on the farm of Mrs. M. Marlin; on the farm of E. Reed, near the village of St. Louis, in Haw Creek township, and the "back-bone" ridge, as it is called, on the farm of J. Remy, west of Burnsville, in Rock Creek township.

The Hawpatch glacial gravel and sand, one of the most extensive and peculiar beds of gravel in the State, is roughly bounded by Flat Rock river on the northwest, and Haw creek on the southeast, and reaching from the White river bottoms to the Shelby county line, a continuous bed of gravel covered with a gravelly black soil, twelve miles long by three miles in average width. On the Columbus and Greensburgh pike a typical view of the surface features of the Hawpatch may be had, and it will be seen that Haw creek does not form any special boundary on the east, but cuts through the gravel, that the immediate, first banks of the creek are from six to eight feet below the second banks that mark the true level of the bed, and that the banks of Clifty creek define the eastern edge. What is true of this cross section will be found true of other places. The actual limits of the Hawpatch gravel are to be found in the range of foot hills of the Knobstone on the west of White river, extending from below the Lowell mills to the northeast of Taylorsville, and the sand ridges and dune like hills on the east, running north from the Clifty creek bridge. Another element that has entered into the formation and largely determined the uniformity and evenness of the surface of this gravel plateau has been the smooth top of the underlying black shale; the shale unlike the other strata of Indiana, is a stony formation of great uniformity of structure that does not weather into rough escarpments of valleys and ridges. An exemplification of this may be seen in the bed of White river, in the vicinity of the Valley mills. The top of the bed is mixed with a strong dark calcareous soil, except where the soil has been washed away in the bed of the creeks, where the gravel is left in purity. Under the soil, generally, comes a bed of adherent gravel and sand, locally known as "hard pan." This conglomerate is due to the cementing together of the particles of sand and gravel by carbonate of lime in the same manner as the conglomerate of the upland gravel, as has already been pointed out. In short, it is the same chemical process that under other circumstances would result in the formation of tufa and stalactites, the interstices between the gravel in the one case acting as the larger cavernous openings do in the other.

Water dissolves carbonate of lime under pressure, and deposits it under opposite conditions. These conditions have occurred in many instances, and, continued for long periods, have cemented the gravel and sand in an impervious stratum of "hard pan," so that we have the apparent anomaly of a pond or marsh covering a gravel bed. Below the "hard pan" and soil is found clean, fine gravel and sand. In many places the sand, or rather very fine gravel, presents a white or ash-blue color. An examination of the white and blue sand, with a magnifier shows the first to be quartzite, and the second, the blue particles derived from the decomposition of the gray granite-like bowlders, all much worn and rounded by attrition. Occasionally mixed with the gravel are pebbles and small bowlders. All the beds, whether upland or lowland, have a large per cent. of chert and limestone fragments, not so much worn as the other materials, of a brownish color on the outside from staining with oxide of iron. The bowlders are frequently in a state of decomposition, and specimens measuring more than a few inches in diameter are seldom or never found. The following section, taken south of Columbus and Greensburg pike, on Haw creek, is very characteristic:

Section on Webber Smith's Farm, Columbus Township.

Soil mixed with gravel	3 ft.
Stratified sand and gravel, with pebbles at the top	6 ft.
Larger pebbles stratified	2 ft.
Fine sand	1 ft.
Stratified gravel to the bed of Haw creek	4 ft.
Total	16 ft.

The top of this section reaches the surface and includes the soil of the second bank of the creek. On the west of the point at which the section was taken, the strata have a uniform thickness; on the other hand the stratification dips slightly to the east, but is everywhere conformable. The following section in the second bank of Clifty creek north of the pike shows the same general arrangement of the strata as the preceding:

Section near Clifty Creek Bridge, Columbus Township.

Soil with gravel	2 ft. 0 in.
Sand and gravel, stratified	1 ft. 0 in.
Coarse gravel and large pebbles in a continuous stratum	0 ft. 6 in.
Stratified sand and gravel	4 ft. 6 in.
Total	8 ft. 0 in.

What is seen at these sections will be found true for the balance of the Hawpatch. Wherever examined on the banks of Flat Rock river, or in digging wells the same evidence of stratification was found, and it will be noticed that while there is occasional evidence of stratification in the upland gravel, such is not by any means the rule, thus placing the two in marked contrast. An excavation for a cellar, No. 414 west side of Washington street, in Columbus, showed that the surface of the gravel was not perfectly level, but marked by hillocks, slight ridges and pocket-like depressions, as if formed by currents of water running in different directions. On the gravel rested a bed of clay, overriding the elevations and dipping down into the depressions. The two strata were very distinct, as if formed under very different conditions. No gravel was noticed in the clay, but its absence may be due to the near vicinity of the river, and is alluvial rather than of the drift period. We can form no very correct estimate of the actual thickness of the Hawpatch gravel as the underlying stone was not seen, nor has it been reached in sinking wells in the deeper parts. Wells have been put down to the depth of fifty and sixty feet in the vicinity of Columbus, and no stone struck. That the bed was once much deeper than now is shown by the mound on the farm of Judge Tunis Quick, one and a half miles west of Clifford, and the Tipton mound in the city of Columbus. The first is twenty-five feet above the surface of the surrounding plain and the second twenty feet. They are the monuments left by the currents of the Terrace epoch, and meters by which we can in part measure what was once the thickness of this great gravel bed. The soil of the Hawpatch has an average thickness of five feet, is dark or black in color, and free from admixture with any but alluvial clays—no glacial clay intervenes between the soil and gravel.

The following section east of the broad ford on Clifty creek shows the stratification and arrangement of the gravel, sand and pebbles of the gravel beds that form the connecting link between that of the uplands and lowlands:

Section at Sarah Bush's Farm, Clay Township.

Soil free from gravel	... ft.	10 in.
Soil and gravel mixed	2 ft.	2 in.
Coarse gravel and pebbles	....	5 in.
Fine gravel and sand	....	2 in.
Coarse gravel	....	5 in.
Fine gravel	....	4 in.
Coarse gravel and sand	1 ft.	3 in.
Fine clean gravel	....	3 in.
Coarse gravel and sand	1 ft.	2 in.
Clean gravel	....	2 in.
Coarse gravel and sand	2 ft.	0 in.
Total	9 ft.	2 in.

Here the stratification is very marked and distinct, and the strata more largely mixed with limestone fragments and chert, than at other places. East of this section on the south bank of Clifty creek a backbone of gravel, above any overflow of the present day, extends for a mile or more. South of Columbus, in Sand Creek and Wayne townships, the gravel and clay is covered with sand to such an extent that no opportunity was had to study the bed, but is doubtless much like that of the last section, and the same range is struck in digging wells in Clay, German and Haw Creek townships. The clay of the Hawpatch region has been washed away, while that of the adjacent beds was left undisturbed, or covered with sand.

Bowlders, or erratic rocks, locally known as "nigger heads" and "blue heads," of the largest size and in greatest numbers are found on the eastern boundary line of the county. A line of bowlders extending from the vicinity of Milford, south into Jennings county, was noted in the early history of the country, and was supposed by some to have been the work of the Indians, who had placed them as some sign or memorial. The largest one seen was on the land of Knox Smiley, just over the Decatur county line. It is of gray granite, and measures six by eleven feet on the surface, and is bedded deep in the earth. Another, on the farm of Henry Mobley, in Clifton township, measures 8x10x6 feet. Bowlders two and three feet in diameter are common, but grow less frequent toward the west, but are rather common in Nineveh township and in the clay banks of White river down to Lowell mills. In composition they are identical with the mass of stones found strewn over the Drift regions of Indiana, Ohio, Illinois and the northwest, the various varieties of granite, syenite, gneiss, etc., metamorphic and plutonic rocks from the Laurentian highlands of Canada, north of the great lakes. The larger ones are usually angular, showing no signs of having been rolled or eroded. The smaller ones are rounded and water worn, and occasionally one is found with a smooth surface and lines of striation.

The glacial, yellow or ferruginous clays of Haw Creek, Clay, Clifty and Rock Creek townships, are light yellow in color, friable when dry and inclined to be sticky when wet. Internately mixed with the clay are fragments of chert and limestone, torn from the underlying Niagara and corniferous strata, together with a large per cent. of metamorphic pebbles of northern origin. In the banks of the creeks and bluffs the clay never shows evidence of stratification, but not infrequently beds of sand and fine gravel are pierced in digging wells and cisterns. A bed of sand two feet thick was found in the Paul Sheets well in Columbus, below forty-five feet of white and bluish clay. These beds of sand are local, occurring in pockets that soon thin out, or are replaced by clay and gravel. The average thickness of the glacial clay, as determined from the average depth in a number of wells, is put at twenty-five feet, and varies from a few feet to many. The top soil, free from gravel, ranges from one to five feet in thickness. The clay is thinnest when subjected to the wash and action of the currents of the terrace epoch, as in the vicinity of Otter creek where the water once flowed across the creek south.

The terrace clays that cap the Knobstone foot hills west of White river, are largely made up of the fine, impalpable sands and alumina arising from the decomposition of the adjacent and underlying aluminous shale. Frequently underlying the terrace clay are beds of glacial origin; especially may they be noticed in the bluffs and hills west of Columbus. Seven feet of red or yellow clay, containing quite a number of specimens of glacial gravel, was exposed in a well at Henry Gross' farm, in Harrison township, at an elevation of one hundred feet above Columbus, and glacial clay has been found near the top of the Wall ridge, but, as a rule, the clay of this region is of a much later date. The terrace clays are white, sticky and form a retentive cold soil, known as "crawfish land."

The blue bowlder clay, recognized everywhere as of glacial origin, has not been seen by us in the county. Perhaps the conditions favorable to the formation of a blue clay did not exist in this immediate vicinity. The yellow glacial clays of Bartholomew county are doubtless in the main the result of the disintegration of the Niagara and corniferous group rocks and the black shale, together with the materials of a foreign origin, without the usual admixture of the products of the blue shales, so common in the lower silurian and sub-carboniferous formations, neither one of which is crossed by the line of denudation that has formed our clays. Blue clays are said to be found south of this county, and probably owe their origin to the base of the Knobstone.

Yellow sand—Molders or ferruginous sand forms an important feature in the surface geology of the county, not only on account of the quantity, which is considerable, but more particularly as the cap of the extreme outlying bluffs on the east and west of the White river valley, and as being the most recent formation and deposits in the succession of time of the Terrace epoch. This deposit of sand marked the close of the Drift period. In physical appearance, where pure as left by the receding waters, and unmixed with humus, carbonaceous clay and other foreign matter, it is always loose and mellow, with a rough feel to the touch—not impalpable—in the vast majority of instances of a yellowish or ochery color, with occasional pockets of white sand, so clean that a shovel full of it will not render a pail of water turbid. The clean yellow sands are those that cap the bluffs and form the higher sand ridges, that have not been disturbed since they were deposited. Examined under the microscope, the fine particles show that they are of metamorphic origin, identical with the coarser sands of the Hawpatch, but without sharp points of crystallization, indicating that they have been water worn and rolled as the other glacial sands have. On the low lands and bottoms, where mixed with the products of the soil and mud of the flood plains and overflows of the rivers, they are dark, in many places after cultivation, black; in others, where much washed, of a light color.

The central line of sand ridges of the county commence at the northwest corner of Clay township, and trend thence south to the north bank of Clifty creek, following the bluffs of the south and west bank as a mantle over the clay to the bridge on the Columbus and Burnsville pike, southeast to the Lutheran church, thence in a general course south between Elizabethtown and Azalia, crossing the county line and connecting with the chain of sand ridges and hills of Jackson county. Through Sand creek township are found parallel ridges ranging north and south, with a spur to the west that is cut by the Azalia and Mineral spring road. By barometric measurement this spur was found to be twenty-five feet above the river bottoms, and is probably forty feet above high water in White river; Elizabethtown by railroad level is seventeen feet above Columbus. The top of the bluff north of the Clifty bridge on the C. & H. pike is by the barometer seventy-five feet above the bed of the creek. These sands modified form the surface soil of Sand creek, and a large part of Wayne township. An isolated, and apparently an anomolous accumulation of yellow sand unmodified is found on the east bluffs of Fall Fork creek, and on both faces of the valley locally known as the "no-head-hollow," a sharp gorge running north and south from the banks of Middle Fork to Fall Fork, above their junction. These bluffs are estimated to be at least one hundred and twenty feet above the bed of the White river valley. A branch of the "no-head-hollow," is known as "fox hollow," here with little labor the fox and ground hog dig their habitations, safe places of retreat in the loose sand. On the farm of Dr. Biddinger, south of David Anderson's mill is a low sand ridge in the bottom, showing that at one time overflows must have been much higher than any of the present day. In the bends of Clifty creek below Fall Fork, especially below Newbern, in the vicinity of Bush's mill, are points and broad accumulations of mixed sand and soil. On the west side of the great White river valley the range of hills between Taylorsville and the Valley mills are covered on the west with yellow sand; in the vicinity of the Lowell mills the same range of hills show only a deposit of clay and clay gravel. The foot hills of the Knobstone west of Walesboro, and again in Wayne township, are sandy.

BURIED TIMBER.

In digging wells all over the eastern townships of the county at an average depth of twenty feet,a bed of black earth is pierced. In appearance it is indentical with a productive surface soil. This *soil bed* is found as a rule, not always, and rests generally on the underlying limestone, but occasionally, as in the neighborhood of Hope, is reported to have a substratum of sand and gravel. In thickness it ranges from one to six feet, and is not so much mixed with gravel and pebbles as the overlying clay. Where this black soil is penetrated, quite frequently pieces of wood, roots, masses of decayed leaves, and a thick muck are found. A large piece of timber was taken from a well on the farm of John E. Galoway, just east of Hartsville; from the well of Francis Galbraith, on the county line east of town; from the well of Prof. Lewis Mobley; from the well of Mr. John Chisler, in Hartsville, and from a number of other wells in Clifty and Rock Creek townships. So common are the remains of an ancient forest that an inquiry in any neighborhood will elicit the fact of leaves and wood being found buried near by. A root is reported to have been taken from the Taylor well, in Columbus, fifty feet down, but such things are not common in the central valley region. No fact connected with the history of the Drift has more indelibly fixed itself on the minds of the masses, and no fact more conclusively convinces the average mind that the whole country on the east line of the county has been subjected to the violent action of water or some other force, at a time long past.

COLLETT GLACIAL RIVER VALLEY.

Commencing at the head waters of Blue river in Henry county, on the long southern slope of the divide that determines and gives direction to the sources of the Great Miami, White Water and the east and west forks of White river, at an elevation of more than 1,200 feet above the mean tide level of the ocean, sets in a broad valley that connects with the valley of the Ohio at Louisville. For this great central Indiana valley, Prof. John L. Campbell, of Wabash College, has suggested the name of Collett Glacial River Valley. Prof. John Collett having been the first to point out the extension of the valley below Jackson county, the honor has been well earned and well bestowed. As the terms Blue river, Driftwood and White river valleys have a local signification only, parts of a grand whole, and all three combined do not convey to the mind the extent of the valley in length or vastness in breadth, there seems to be a real necessity for a more general term. To fill the want we shall apply to the region under consideration the name, Collett Glacial River Valley.

This valley is roughly bounded on the east by the high ridge of the western outcrops of the Hudson river groups of the lower Silurian, and on the west by the eastern outcrop of the Knobstone groups of the Sub-carboniferous period. By the natural drainage of the country its upper part above the Bartholomew and Jackson county lines, embraces all the territory drained by East White river. In Jackson and Scott counties the valley is cut at right angles by the Muscatatuck river, and its tributaries flowing west through the Knobs. To a proper understanding of the wonderful forces in action during the Glacial period, it will be well to first get an idea of the amount of erosion and denudation that has taken place since the emergence of the rocks of our country from the bed of the ocean, beneath which they were formed. To do this some idea of the depth of the valley may be had by a comparison of the height of Columbus and other points above tide level, with the ridges on the east and west. This can be done by a study of the railroad elevation on the C., I., St. L. & C. R. R.. published in Indiana Geological Report for 1878, the J., M. & I. and branches, published herewith. According to the survey of the main line of the J., M. & I. road, in round numbers, the base of the rail at the Columbus depot is 643 feet above tide level and the bed of White river 34 feet less, or 609 feet above the ocean. Starting with these data we find the summit between the West White river and Sugar creek on the

C., I., St. L. & C. road, 227 feet above Columbus and 109 above the surface of Blue river at Shelbyville, the summit between Flat Rock creek and Clifty creek 273 feet, the surface of Flat Rock at Rushville 323 feet, at St. Paul 176 feet, Clifty creek at Adam's Station 258 feet, and the ground in Greensburgh 323 feet above Columbus. The summit between Sand creek and Salt creek is given as the highest point on the C., I., St. L. & C. road at 1079 feet; 436 above Columbus. The altitude of Pierceville station on the O. &. M. Ry. is given at 1009 feet above tide level, which is 564 feet above the bed of the Great Miami river bridge, 404 feet above Seymour, 442 feet above the bed of White river at Rockford, and 366 feet above the depot at Columbus. The Knobstone ridges on the west, range in altitude from 300 to 400 feet above the bed of White river and at the highest point in Brown County, the Weed Patch Knob is 1173 feet above the ocean (Prof. Collett), and 510 feet above Columbus. The Knob west of New Albany is given as 500 feet above high water of the Ohio river, (Prof. R. Owen). From the above elevations, that may be relied upon as approximately correct, an idea may be formed of the extent of the Glacial river valley. It has a width of over 40 miles measuring on an east and west air line through Columbus, from the Wall ridge of the Knobstone to the Lower Silurian ridge north of Pierceville, in Ripley County, and a depression of over four hundred feet below an air line in the lowest parts of the White river bottoms. In this valley we find nearly the whole of Bartholomew County and fully one-third, through the center of the county north and south, a broad level plain at the very bottom of the old Glacial valley. That the trough of this ancient river was once at a lower level than it is now is shown by the present river flowing over the sand and gravel, and at no point below Catfish Falls cutting through to the underlying rock north of the Jackson County line. It is not probable that the thickness of the gravel and sand below the present river bed is very great, or has been silted up as the Ohio at Louisville and points above; where the filling up with sand, gravel and clay has been to such an extent as to warrant the assertion that the Ohio, throughout its entire course, runs in a valley that has been cut nowhere less than 150 feet below the present level of the river, (Prof.

Newberry). It is proven that the old channel of White rive at some period of its history, cut the Black Shale at a lowe level than it now does at Rockford, by borings for water a Seymour, that have been sunk in the gravel below the presen bed of the river, and 25 feet below at Columbus, and no roc found. The extent of the Glacial river valley at the close o Paleozoic time is largely a matter of speculation; but that valley of considerable depth existed in the pre-glacial period and gave direction to ice currents, is proven by the mass o drift material found far down the valley south of and belo that stopped by the Knobstone barrier of the west.

DYNAMICS OF THE DRIFT.

In the presentation of the dynamical geology of the Dri period, I shall adopt and apply those theories of the author that seem best to explain and agree with the phenomena presented by the facts detailed above.

At a period of time long past and variously estimated a 200,000 to 4,200,000 years ago, when the surface of the continent was elevated from 500 to 2,000 feet above the presen ocean level, the ice cap that now covers the frozen regions o the far away Arctic zone, was extended south in a general shee to the Highlands of Canada. From the foot of the glacier o the Laurentian hills, prolongations flowed south, southwest and southeast. That flowing across northern and central Indiana from the striæ left on the rocks, over which i passed, seems to have had a southern or southeastern cours The primary glacier of Indiana was, doubtless, continuous wit that of Ohio, if not in direction of the flow, at least in action and covered the Lower Silurian ridge as far south as Riple county. On the west Collett Glacial river valley, the Bea Blossom ridge of the Brown county Knobstone, and the northern side of the Wall ridge in Nineveh township, were the barriers, beyond which the central portion of the Indiana glacie never passed. Here against the everlasting hills the ice pile up in mass over 400 feet thick (Prof. Collett*); but found a depression to the east and south, across and down which a lob extended in force, scoring and planing the face of the under lying limestone and shale. Down the preglacial valley the ice flow reached nearly, if not quite, to Louisville, and that this great extension of the glacier was of long duration is shown by the thickness of the glacial clay and immense amount of chert gravel and pebbles contained in it, derived from the Corniferous and Niagara limestone over which it passed, grinding and pulverizing the face of the earth. Some idea of the immensity of time, during which the glacier was in action and of the amount of denudation that took place, may be formed when it is remembered the chert gravel and pebbles that form so large a per cent. of the Drift clay and other materials, existed only in a small per cent. in the rocks, from which they were derived. During this long period the Glacial valley was deepened and extended, scooped out of the solid rock by the mighty power of moving ice. At the bottom of the icy river was borne the rounded pebbles and striated bowlders of metamorphic rocks torn from their home north of the present great lakes, constantly were added to these, the fragments of the sedimentary strata, over which the glacier glided, on its top rode huge masses of angular stones, unworn bowlders.

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* Ind. Geol. Rep. 1874—Brown County.

In the fullness of time came a change, the climax of the Glacial epoch had been reached, heat began to displace the frozen mantle, and fogs that hung like a pall over the face of nature, the land began to subside and the ice disappeared from the Silurian ridge on the east. The line of numerous large, angular, unworn bowlders, unmodified beds of upland gravel and abundance of glacial clay, found in greatest force along the eastern boundary of the county, and continued into Jennings, are proof of their accumulation at the edge of a local glacier, that they are the remains of a lateral moraine. The terminal moraine is found in the line of bowlders and sand south of the Muscatatuck river in Scott county, in the vicinity of Scottsburgh, Vienna and Lexington, and on the head waters of Pigeon Roost creek. (Prof. Borden). The lateral moraine in Bartholomew county is elevated from one hundred to one hundred and twenty feet, and the terminal moraine is shown by the survey of the J., M. & I. railroad, at the water divide below Vienna, to be ninety-five feet above Columbus. The water divide south of the Muscatatuck, in a large measure, determined the foot of Collett glacial river. Another explanation suggested for the great abundance of bowlders seen on the east side of the county, is that the glacial clay subsequent to its deposition, with bowlders buried beneath the surface, has been washed away and the bowlders left lying on the surface. But this explanation does meet the facts in the case; while there is evidence of the long continued action of water, there is no evidence that the clay in the bowlder region has been washed away, but is as thick, if not thicker, than at other points. The strongest proof of the existence of a lateral moraine is that bowlders of a large size are rare on the east in the vicinity of Greensburg, and especially on the west in the west part of Clay township, where the land is found at the same or a lower level, and the clay as much or more liable to have been washed than any other beds in the valley. If ever imbedded in the clay in like proportion, the wearing away of the gravelly banks and beds of the streams and rivulets would have unearthed them.

The lateral moraine on the west of the valley can only be traced to the foot hills west of Columbus. Bowlders of medium size are found near the Dowell hill quarries in Harrison township, and specimens of larger size are not infrequent above, and common at the Valley mills. In digging for an extension of the race at the Valley mills, several bowlders of large size were removed. Some of them were found resting on the black shale and the others bedded in the terrace clay. That there is a line of buried bowlders on the west, the remains of a lateral moraine covered by the terrace clays of a later epoch, is not impossible, but improbable. In the southwest part of the county, at points where the clay was thin and washed, a careful search and inquiry failed in finding them. At Rockford the clay is cut through to the bed rock in the same manner as the Lowell mills and above, and is in the line of the western moraine, if one ever existed. Yet, Prof. E. T. Cox says, (Ind. Geol. Rep., 1874): "I saw no erratics more than a foot in diameter in Jackson county, and such specimens are very rare." The theory that best agrees with the observed facts, is that the course of the ice-flow of the general glacier as it came down from the regions of Lake Superior and Lake Michigan, continued in the same southeast direction, across the State and across the glacial valley, and that for a time the foot of the glacier rested against the east side of the valley. The piling of the mass of ice against the Bean Blossom and Wall ridges, at an angle with the direct line of the glacier flow, would have the effect to stop and cut off the detritus of the lateral moraine. On the south and west, the great mass of bowlders would accumulate at the foot of the piling ice and but few reach the valley from that side. Another result of the accumulation of ice on the Brown and Johnson county line, would be to deflect the flow to the east and increase its velocity. The cross flow of ice and that down the valley to the south, was shorn of its western and lateral moraine by the Knobstone hills; hence no bowlders on that side of the valley below Columbus.

It is a well known geological fact that at the foot of the ice sheet, all over the northwest, great valley and river beds have been cut very much beyond the capacity to accommodate the streams now flowing through them; some of these ancient river beds have been silted by accumulations of sand and gravel, and the rivers flow at a higher level than they once did; others still find their old rocky bed. To the latter class belong Clifty creek and its tributaries, Fall Fork and Duck creek. The Clifty creek valley and bed is cut through from twenty to forty feet of Corniferous, and from ten to twenty-five feet of hard crystalline Niagara limestone, and the same is true of Fall Fork creek. Perhaps nothing connected with the surface geology of the county is more singular than the beds of these creeks, great valleys eroded in the solid stone, through which now flow insignificant rivulets that are dry for almost half the year. The Duck creek valley has a capacity to carry a volume of water as great as that flowing down White river at flood tide. It is evident that the foot of the cross flow or cross glacier, as we may call it, must have rested for a long time on and near the banks of Clifty creek, alternately advancing and receding, with the heat of summer and cold of winter, across Haw Creek, Clay and Clifty townships, while at the foot ran mighty rivers of ice water. No other hypothesis offers an explanation of the vast amount of local erosion and denudation that has here taken place. It is probable that the ice flow down the Glacial valley was continued long after the cross glacier foot ceased to exist, as an ice tongue of the decadent period, shorn of its moraines, but still laden with metamorphic gravel and recent limestone pebbles. It was the long continued action of the direct valley glacier that cut away from forty to fifty feet of Corniferous limestone down to black shale, west of Clay township, planing and polishing the broad, smooth floor of the valley, now covered by the Hawpatch and lower White river bottoms.

As the general glacial sheet receded to the north, the ferruginous glacial clay and remodified upland gravel beds were left on the higher lands. The decadence of the Valley glacier left vast quantities of gravel that was more or less modified and stratified by the great rivers of ice water, that the increased heat of summer sent down from the melting snow and ice.

Of the various theories that have been proposed in explanation of the occurence of buried soil and timber, "ancient forest beds," found at many places in the western Drift, that one is adopted provisionally by the writer, which seems best to agree with the facts. It is well known that the glacial clay of this vicinity where exposed to the sunlight and air, will soon support vegetable life. The ice sheet receding through the influence of a warmer climate, the exposed ridges were soon clothed with a soil and growth of vegetation, that had continued to exist further south through the climax of the cold period. Along with the forest growth came the mammoth, mastodon, reindeer, great beaver and other animals now extinct. After the general ice sheet had disappeared from a comparatively narrow strip of territory on the southern edge of the Drift region, through changes in the climate, about the exact nature of which it is not necessary here to speculate, there was a recurrence of the extreme cold, the retreat of the glacier was arrested: over the exposed Drift, on which a forest was growing, came an extension of the ice flow of the north, the glacial clay was rearranged, the so-called ancient soil and forest buried in some places, and wholly obliterated in others. A few things connected with the history of the forest bed seem to lend color to the above theory. First, the buried soil and timber is covered with glacial clay and gravel, and is strictly a phenomenon of the Drift period, we have no reports of buried timber outside of the Drift area. Second, the forest beds of Indiana and Ohio, except where possibly buried under the old deltas of Lake Erie, are found only over a narrow strip of country confined to the southern limits of the Drift. These facts militate the theory of a general submergence. By a submergence all the forest territory south of the Drift would have been buried. A local central lake, devoid of currents, could not have rearranged the glacial clay, and it is hard to comprehend how a local lake was confined to few counties on the southern border of Ohio and Indiana, no barrier has been pointed out sufficient to dam up a lake whose currents and eddies could have swept over the Lower Silurian hills. An inter-glacial period of a general forest growth certainly would have left scattered remains all over the Drift region, so far as Ohio and Indiana are concerned, with the exceptions mentioned, no such remains have been reported.

That the great body of water flowing from the foot of the receding *recurrent* glacier, further modified the lowland gravel beds of the Glacial Valley and washed vast quantities of it further down the valley, is shown by the so called Indian gravel mounds on the farm of Judge Tunis Quick, and Tipton hill in Columbus, gauges that mark what was once the depth and extent of the deposit. The Judge Quick mound having an elevation of twenty-five feet above the general surface of the surrounding country, presents a sharp bluff to the north, a gently sloping talus to the south and a swale for surface drainage on the east, all showing that the eroding power has been water, and that the currents that have cut away the gravel and left the hill standing, came from the north down the Glacial Valley.

When the glacier had retreated to the water divide, six hundred feet above Columbus, of Randolph and Henry counties, and covered the highlands with melting ice, the collected waters found an outlet through the White River valley. Down the valley of the east fork came sweeping currents and floods carrying quantities of yellow sand, that was left on the plains and hills where the flood current was broken and deflected to the right or left. The bluffs of Clifty creek on the Clay township line formed the base of an eddy of slack waters *above*, that gave origin to the ridge of sand hills that extends north from the vicinity of the Columbus and Greensburgh pike bridge. The retardation of the current of the flood caused the deposition of sand on the bluff sides and in the valley of Middle Fork creek, on the hills east and north of the Valley Mills, in German township, and on the bluffs west of and below Walesboro. But the great mass of sand was carried beyond the points mentioned, by the torrent and left in the hills and ridges of Sand Creek township, in the slack water formed *below* the Clifty creek bluffs. Like influences together with the change in the course of the valley to the west through Jackson county, caused heavy deposits east and south of the more modern bed of White river. Doubtless much of the sand found over Sand Creek and Wayne township has been spread since the close of the Terrace epoch by the rains and floods of more recent times.

The location of the Terrace clay, on the west side of the valley and in the White creek slashes, gives a clue to their origin, and point to the conclusion that they are the products of the impalpable sand and finer materials, deposited from the sluggish waters of the Glacial river, while the coarser materials were carried further to the east, where the main current flowed. This clay has been added to and modified by materials derived from the adjacent Knobstone hills. It is not necessary to invoke the existence of a great lake, the protecting influences of the Wall ridge were sufficient to favor the formation of bayous, great pools, and slashes beneath which the fine, whitish, sticky clay was deposited.

The Glacial period closed with the Terrace epoch. That the deposition of the yellow or ferruginous sand was the last record made by the floods of the Glacial valley that reached from the bluffs of Fall Fork creek to the Knobstone hills of the west is shown by the sand resting on and above the glacial clay. In depth the flood must have exceeded one hundred and fifty feet, and that the flow was from the north to the south, a great rushing torrent, is shown by sand ridges only being left in the retarded current *above* and *below* the bluffs of Clifty creek. Such must have been the closing scene of many winters of ice and snow, the opening of spring that has ever since been followed by a perennial climate of summer as compared with that of the preceding age*.

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* The reader in studying Dr. Elrod's valuable and interesting report, will observe that in some cases his observation differs from conclusions heretofore given. The subject of the drift will require much study, years of labor, and a wide area for observation. The opposing deductions are here given to arouse study and investigation.—COLLETT.

RECENT PERIOD.

ALLUVIUM.

The alluvial deposits of the East White river valley are made up of the varied clays, sand and gravel which are further comminuted by the action of the water, together with great stores of organic matter that are swept down by the rain storms and carried by the floods and overflows over the fat acres of the first river bottoms; thus forever adding to their perennial greenness, at the expense of hills and valleys east and west. The alluvium of the creeks of the east part of the county, is unimportant as their rocky banks are seldom or never overflowed; that of the creeks of the west can not be separated from the muddy terrace clay banks through which they flow! An overflow of the mud banks of these creeks is but the addition of an other layer of sticky clay and impalpable sand, a rearranging of the old materials and the addition of decaying vegetable matter. The calcareous soil of the hawpatch is of local origin, from the decomposition of the contained limestone pebbles and metamorphic gravel, to which has been added ages of vegetable, growth, carbonaceous matter that has imparted a dark color to the whole mass.

PALEOZOIC GEOLOGY.

DIP AND CONNECTED SECTION.

Starting with the datum, derived from railroad surveys, that the bed of Clifty creek at Hartsville is 112 feet above the mouth; we find the top of the Niagara group limestones 94 feet below the same horizon at St. Paul, eleven miles north, and that the dip to the south is near eight and one-half feet to the mile. We find the level of the Niagara limestone eight miles east, at Adams Station, to be 156 feet above that of Hartsville, which gives the dip to the west at nineteen feet to the mile. From these measurements we estimate the general dip to be to the southwest at the rate of fifteen feet to the mile.

The following connected section of the rocks of the county is made up from measurements made in taking the local sections, and presents at one view the various strata and their average thickness. The numbers in the first column are referred to in the following pages by the abbreviation, C. S., No. —, and will enable the reader by reference, to see just what age, period, epoch and stratum, where not more fully given, is under consideration in the local details.

Connected Section of Bartholomew County.

CARBONIFEROUS AGE.

SUB-CARONIFEROUS PERIOD.

Knobstone Group or Epoch.

1.	Sandstone, coarse textured with bands of iron ore and shale partings	95 ft.
2.	Sandstone, even bedded, light colored quarry stone	40 ft.
3.	Shale and sandstone in thin beds	50 ft.
4.	Shale and iron ore	90 ft.
5.	Blue aluminous shale and calcareous goniatite bed	85 ft.

DEVONIAN AGE.

HAMILTON PERIOD.

Genesee Epoch.

6.	Black slate	80 ft.

CORNIFEROUS PERIOD.

Corniferous Group.

7.	Blue crystalline quarry stone, North Vernon stone, Upper Corniferous	10 ft.
8.	Light blue crystalline limestone, middle corniferous	12 ft.
9.	Gray or earth colored limestone, soft at the top, locally hard and ochery in color, lower corniferous	40 ft.

SILURIAN AGE.

UPPER SILURIAN DIVISION.

NIAGARA PERIOD.

Niagara Group or Epoch.

10.	Calcareous shale, fossil beds	6 ft.
11.	Blue quarry stone, locally brownish in color at the top	30 ft.
	Total	538 ft.

LOCAL DETAILS.

NIAGARA GROUP.

In lithological characters the blue quarry stones of the Niagara group vary from massive to thin bedded crystalline magnesian limestone with local bands of chert. Wherever it is exposed, it has been found very free from shaly or clay-partings and breaks with a square angular fracture. In physical appearance and composition, it is subject to change, in some localities being an even bedded homogeneous rock, and at others, only a few hundred feet removed, irregular, and the mass made up of chert bands and nodules. At the top of the Niagara limestone the beds change in most places by imperceptible degrees, and at others, abruptly into a hard refractory ochery-colored pseudo-limestone that occurs in thin or massive layers, generally shelly, with a conchoidal fracture. In color or structure, it seems to be persistent, showing in all the outcrops, in appearance it is very much like the base of the lower member of the Corniferous group overlying the calcareous shale, nodules of calcite, crystallized carbonate of lime, of great beauty are common to both. The calcareous shales, No. 10 C. S., is not always found in place, is very variable in thickness, and composition. Where not too much exposed to the air the color is blue, where mixed with the surface soils and weathered, is a yellowish clay. It is thin bedded, splitting into thiner laminæ, uniform in structure, where non-fossiliferous sometimes a sticky plastic clay, and at other places intercalated with plates of fossiliferous limestone and nodules and cubes of pyrites, ferrum sulphide. The surface of the blue limestone is not a uniform level; at the foot of the Farr and Stucker holes in Clifty creek, the top of the outcrop is just above low water mark, while at the bend of the creek between the two, below Hartsville, a ridge is cut through twenty-five feet in thickness. There is no evidence that these irregularities are synclinal or anticlinal axes, but slight ridges left at the bottom of the ocean before the overlying Corniferous was deposited, hence there is probably a slight want of conformability between the two groups of stone.

The Niagara group stones were formed from the sediment of an interior ocean, whose eastern shore line was formed by th hills of Franklin and Ripley counties, hills that were then an have ever since reared their heads above the tide level. Th nearest outcrop of the lower Silurian is seen in the vicinity Westport, a few miles east of the Bartholomew county lin As the average thickness of the strata decrease as we go eas thinning out to a knife blade deposit, we have evidence that th waters of the ocean were shallow, but must have been ve pure and quiet to favor the formation of crystalline rocks; th process of formation must have been slow and long continu to allow the growth of life, the fragments of whose remai are here found entombed in the living rocks. As the Niaga group limestone emerged from the shallow seas, a change the purity of the water and irregularity of the limestone b caused deposits of argillaceous clay sediment to take place the pockets and depressions, hence the calcareous shale is va able in thicknes within a few feet and occasionally wholly wan ing, where the conditions were not favorable to the accumulati of a muddy sediment. A very perfect specimen of *Euca ptocrinus crassus* found in the calcareous shale, lying horizontal with the root and stem of another individual growing at rig angles from the calyx, a *Platyostoma niagarense* covered ov with the delicate tracery of *Paleschara*, and on this the roo of a crinoid, together with the great numbers of fossils take from these beds, show that the accumulation was very slow an that more than one generation of animal life passed before th last was covered by sediment.

All the members of the Niagara group are fossiliferous an the calcareous shale, highly so. The cephalopod shells. *Orth ceras crebescens*, H., *O.*, *annulatum*, Sow., and *Gyroceras elroa* White, by their size, form and members are the most conspi uous, and are characteristic of the Niagara blue limeston They are found in greatest abundance near the top of th group in the thin flagging stone. Occasional specimens *Atrypa reticularis*, Linn., *Strophostylus cyclostomus*, H., *Meristi nitida*, H., *Eucalyptocrinus crassus*, H., and a few very small *St phanocrinus gemiformis*, H., are found in the upper member but not in abundance, nor are the corals or trilobites commo *Calymene niagarensis*, H., has been found. No attempt will he be made to give a list of the fossils of the calcareous shale, su fice it to say that all the above named species are common, except the cephalopods and stephanocrinus.

The Niagara group limestone outcrops in the bed and banks of Clifty creek from the southwest corner of section 2, township 9 north, range 7 east, to the Decatur county line at Possum Glory, up Fall Fork creek to Anderson's falls, up Middle Fork to Long's falls, in Boner's branch to the cemetery road east of the college, up Hiner's branch to the bluffs on the south, and up the valleys and ravines for a short distance on either side of Clifty creek. No other outcrops are to be seen on Duck creek or Haw creek, and but for the valley of Clifty creek all the members of the Niagara group would be buried out of sight by the superincumbent corniferous limestone.

As the Oriskany sandstone period has been referred to the upper Silurian rather than the Devonian age by most modern geologists, perhaps a word may not be out of place as to its occurrence or non-occurrence in Bartholomew county. If it occurs it should be found between what has been recognized universally as the Niagara and Corniferous groups of limestone. On lithological grounds it is excluded if we look for it as a sandstone. No sandstone occurs on Clifty creek where the two groups are in contact, the one above the other. In Southern Illinois the Oriskany is described as a "silicious limestone," in Ohio as a "coarse saccharoidal sandstone," neither of which can apply to any of our rocks. The presence of the calcareous shale settles the age of the limestone below it. The stone above is used down to the very base, at the Arbuckle Kiln, near Hartsville, as a lime rock, good specimens of *Conocardium trigonale*, H. *Zaphrentis gigantea*, Raf., and other well known Corniferous corals have been found in the stone resting immediately on the calcareous shale. It is true the lower member of the Corniferous group has a "rough and hard dirty look, especially after weathering" (Dana), but no other characters in common with the Oriskany.

Section at Jesse Mobley's Quarry, Clifty Township.

Gray, soft limestone, lower division of the Corniferous group, heavy bedded	2 ft. 2 in.
Hard, ochery, colored stone, No. 9, C. S., with calcite nodules, breaking into wedge shaped shelly pieces	3 ft.

Even bedded, bluish quarry stone, Niagara group, in ledges from 2 to 4 inches thick, readily splitting into good flagging	2 ft.	4 in.
Massive quarry stone ranging from 4 to 6 inches in thickness, good building stone, No. 11, C. S.	2 ft.	9 in.
Dark blue stone, soft when first quarried, hardening on exposure		6 in.
To bed of Clifty creek	4 ft.	
Total	14 ft.	9 in.

In the above section the calcareous shale is wanting, and it is with some doubt we refer the ochery colored limestone to the Corniferous group, but as it is identical in lithological characters with the base of No. 9 of the connected section, this is probably its true place. No fossils of any kind were seen.

Section at Turn Hole, Clifty Creek, Clifty Township.

Soil and covered space, estimated	40 ft.	0 in.
Massive soft limestone, lower division of the Corniferous group	2 ft.	2 in.
Massive soft limestone, lower division of the Corniferous group	0 ft.	7 in.
Massive stone at top, shelly at the bottom, No. 9, C. S.	1 ft.	9 in.
Calcareous shale, fossil bed	5 ft.	8 in.
Massive brownish pseudo limestone, No. 11, C. S.	0 ft.	11 in.
Massive blue limestone, No. 11, C. S.	0 ft.	9 in.
Massive limestone, flagging at bottom	0 ft.	11 in.
Massive bed with chert, No. 11, C. S.	1 ft.	5 in.
Niagara group limestone to creek bed	2 ft.	6 in.
Total	56 ft.	8 in.

The quarry stone at this place has frequent bands of chert that very much increase in the outcrop above on the east side of the bend of the creek. By the following section taken on the west side of the creek, the changeable character of the stone is seen in a few hundred feet.

Section at Lower End of Tarr Hole, Clifty Creek, Clifty Township.

Soil	00 ft.	00 in.
Massive soft stone, lower division of the Corniferous group	2 ft.	0 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	9 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	6 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	5 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	8 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	4 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	6 in.
Gray stone, bedding irregular, No. 9, C. S	0 ft.	7 in.
Gray stone, bedding irregular, No. 9, C. S., brownish at bottom	0 ft.	7 in.
Calcareous shale, fossiliferous beds of the Niagara group	6 ft.	0 in.
Ochery-colored pseudo-limestone, hard and shelly, No. 11, C. S	1 ft.	5 in.
Massive blue quarry stone, very even bedded, splendid building stone, free from chert, No. 11, C. S	1 ft.	10 in.
Quarry stone to bed of creek	1 ft.	0 in.
Total	16 ft.	7 in.

The one foot and ten inches ledge of the above section is a persistent stone of uniform texture and outcrop for a distance of near two miles up the creek, showing in bold and overhanging escarpments where the underlying beds have been less resistant to the action of the weathering process; now appearing on the right bank and again on the left in the bends of the meandering stream. It is evident from the boldness of the square face and sharp angles this stone presents, especially in the bend west of Henry Mobley's place, that it is a building stone that will last for ages without change. At points the ledge increases in thickness and sometimes appears as if divided by seams into thinner strata but is still massive and resistent to atmospheric influences. Most excellent flagging and thin building stone has been taken out of the beds on the farm of Henry Mobley near Hartsville, and its superior quality as a fencing stone demonstrated in the fence east of the pike.

Section at Anderson's Falls, Fall Fork Creek, Clifty Township.

Soil	00 ft. 00 in.
Gray massive stone, lower division of the corniferous group to the bed of creek above the falls	3 ft. 00 in.
Massive gray limestone hard in appearance	5 ft. 00 in.
Calcareous shale, Niagara group, in their *laminæ fossiliferous*	4 ft. 00 in.
Even bedded Niagara group limestone	2 ft. 00 in.
Total	14 ft. 00 in.

A few yards above the falls the corniferous gray stone, that forms the bed of the creek, thickens in the bank to six and eight feet, and on the outside has a "hard and dirty look" where covered with minute growth of lichens: here the characteristic appearance of the lower division of the corniferous may be seen in the rough bed of the stream caused by the weathered and rounded tops of the square and irregular blocks reminding one of a pavement of huge cobble stones. The Anderson falls are remarkable as being in a small way the geological equivalent of the Niagara falls shale and limestone. Here as well as at the great falls of Niagara may be seen the same processes in action, that in the one case has carried the falls back from Queenstown, Canada, seven miles, and in the other two or three hundred feet by the more rapid erosion of the soft underlying shale and breaking down of the harder superincumbent rock, great blocks of which lie in the channel below the falls, and in both cases the streams cut across or against the dip. From the foot of the falls to the mouth of Middle Fork, the creek runs north and apparently toward a synclinal axis, that is due to an irregularity in the surface of the top members of the Niagara group, that are slightly unconformable with the strata above. At the falls the creek bed is over thirty feet wide with sharp overhanging mural front over which the water pours at flood height with a great roar, falling twelve or thirteen feet into the pool below, presenting a pleasing if not a grand spectacle. All the elements are present, of a first class picturesque resort, especially in summer, when the surrounding valleys are covered with verdure, but one, a lack of water to bring out the beauties of the falls, just at the time people feel most inclined to seek such places.

During ordinary summers, Fall Fork dwindles to a lazy rivulet, playing hide and seek with the rocks of its stony bed, in very dry seasons it vanishes into thin air. But while the *dilettante* pleasure seeker might be disappointed, not so the geological specimen hunter whose work would be favored by the absence of water, and the shale that reaches the bed of the creek left bare. Good specimens of *Eucalyptocrinus crassus*, H., *Glyptaster inornatus*, H., *Rhodocrinus melissa*, H., and very fine crinoid roots are not rare, and an occasional perfect trilobite has been found. All the various species of brachiopods common to the calcareous shale are abundant. Picnic parties will find one of the finest chalybeat springs in the State below the falls in the bed of the creek, where a profusion of the coolest water bubbles up from an unknown depth.

Section at Long's Falls, Middle Fork Creek, Clifty Township.

Grayish and ocher colored shelly stone, lower division of the Corniferous group	4 ft. 00 in.
Calcareous shale Niagara group, non-fossiliferous, weathering further down the creek to a yellowish clay	2 ft. 00 in.
Yellowish shelly stone with chert bands at the top No. 11, C. S.,	1 ft. 6 in.
Massive, even bedded blue quarry limestone, in ledges from two to fifteen inches thick, good building and flagging stone	8 ft. 00 in.
Total	15 ft. 00 in.

These falls are in a small way the counterpart of the Anderson falls, and such cascades, rather than falls, are common to nearly all the valleys and ravines where the calcareous shale forms a part of the outcrop and has weathered so as to leave unsupported the overlying Corniferous rock, that has a tendency to break in huge blocks with a square precipitous front. Examples of the square fracture may be seen on Boner's branch south of the College and on Webber's branch. No better evidence of the resistance, to the action of air and water of the blue limestone can be seen than is here presented, the running water more or less mixed with gravel and sand has scarcely left a ripple mark on the surface, level as a barn floor or rounded the square edge of the exposed strata.

In the east bank of Fall Fork creek at David Anderson's mill the upper members of the blue Niagara limestone, are replaced by bands and nodules of white chert, that breaks into smaller fragments on exposure, in appearance not unlike an imperfectly slacked lime rock.

Section at Reese Mobley's Quarry, Clifty Township.

Soil and covered space	0 ft.	0 in.
Top ledge, blue limestone, Niagara group	0 ft.	6 in.
Blue massive quarry limestone	1 ft.	7 in.
Blue massive quarry limestone	1 ft.	4 in.
Blue massive quarry limestone	0 ft.	5 in.
Blue massive quarry limestone	0 ft.	5 in.
Blue massive quarry limestone	1 ft.	4 in.
Blue massive quarry limestone	0 ft.	10 in.
Blue massive quarry limestone	1 ft.	0 in.
Blue massive quarry limestone	0 ft.	7 in.
To bed of the creek, thin bedded stone with local bands of chert	6 ft.	0 in.
Total	14 ft.	0 in.

The ten-inch ledge of this section is of remarkably uniform structure, free from hard nodules and "glass seams," and works kindly under the hammer. Mr. Mason, an old experienced quarryman and practical mason, says that it is "one of the best limestones in the world." Only three feet of the front of the ledge had to be discarded in opening the quarry, showing that a building erected from such stone in this climate would resist the ravages of time for ages. A specimen of work from this ledge may be seen in the water tables and window sills of E. D. Weinland's new brick store in Hartsville. All the ledges of this section are most excellent quarry stone for general purposes.

Section at John Graham's Quarry, Hartsville, Haw Creek Township.

Soil and covered space	0 ft.	0 in.
Yellow clay equivalent of the calcareous shale, fossiliferous	3 ft.	0 in.

Ochrey colored limestone with nodules of calcite, No. 11, C. S	0 ft. 10 in.
Blue quarry stone, massive and even bedded, No. 11, C. S	1 ft. 3 in.
Blue quarry stone, massive and even bedded, No. 11, C. S	0 ft. 7 in.
Blue quarry stone, massive and even bedded, No. 11, C. S	0 ft. 10 in.
Blue quarry stone, massive and even bedded, No. 11, C. S	0 ft. 10 in.
To the bed of Clifty creek, good flagging and building stone No. 11, C. S	20 ft. 0 in.
Total	25 ft. 2 in.

The out-crop at the bottom of Boner's branch at the south end of West street shows a continuous section through twelve feet of Niagara limestone and eight feet of the lower division of the Corniferous lying conformable, without the intervening calcareous shale. Four feet of the Niagara is here replaced by chert unmixed with limestone.

Section South of Hartsville University, Haw Creek Township.

Soil and covered space	0 ft. 0 in.
Lower division of the Corniferous group; dirty gray, soft stone in thick ledges, shelly near the base, No. 9, C. S	17 ft. 0 in.
Calcareous shale, wanting	0 ft. 0 in.
Niagara group limestone, in massive and thin strata ochery-colored, coarse stone near the top, base uniform in bedding and structure, good quarry stone, No. 11, C. S	6 ft. 0 in.
Total	21 ft. 0 in.

No calcareous shale was here seen, and the same is true of the clay shale, that should be found in the banks below, if the conditions favorable to its formation ever existed. Below this section the gorge opens out into a broader valley from which ten to twelve feet of solid crystalline limestone has been removed, leaving a basin shaped excavation connected with Clifty creek by a narrow outlet. No better example than is here presented, anywhere offers of the powerful local action of some eroding agent, other than water alone; we have already shown that agent was doubtless *ice*.

Section at Arbuckle's Lime Kiln, Haw Creek Township.

Soil and covered space	0 ft.	0 in.
Weathered gray stone, lower division of the Corniferous group, massive and even bedded, quarried and used for burning to lime	1 ft.	4 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	4 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	1 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	8 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime, with calcite and corals	2 ft.	10 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime with calcite and corals	0 ft.	10 in.
Covered space, place of the calcareous shale that shows as yellowish calcareous clay in the south bank of the quarry, No. 10, C. S.	3 ft.	0 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	1 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	2 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	2 in.
Blue building stone	0 ft.	9 in.
Blue building stone with chert band	1 ft.	2 in.
Blue building stone homogeneous	0 ft.	10 in.
Blue building stone homogeneous	0 ft.	10 in.
Total	13 ft.	9 in.

The weathered members of the Corniferous are here true rotten stones of a dirty earthy appearance, in which many of the corals are replaced by calcite, especially in the lower beds. The whole out-crop above the calcareous clay, is soft, easily quarried, and makes a most excellent lime. The Niagara building stone is a beautiful blue heavy stone, apparently very even in structure. Across the creek is a bold escarpment of "cliff-rock," Niagara group below, and Corniferous above, from which a little stone has been quarried.

On the east bank of Clifty creek just below the mouth of Hiner's branch is an out-crop that shows the finest flagging any where seen, great yellowish slabs, smooth as a board, of any desirable thickness.

Section at Stucker Hole, Clifty Creek, Haw Creek Township.

Soil and covered space to top of the bluff, estimated..	30 ft. 0 in.
Lower division of the corniferous group, weathered soft, massive stone, fossiliferous......................	6 ft. 0 in.
Calcareous shale No. 10, C. S., highly fossiliferous at the base and upper end of the outcrop.........	4 ft. 0 in.
Blue Niagara group limestone, in ledges ranging from one to four inches in thickness to bed of the creek..	2 ft. 0 in.
Total	42 ft. 0 in.

Above the Stucker hole good quarry stone can be had at many points, notably in a little ravine just above Critzer's mill. A peculiarity not noticed at other places was here seen, in one of the ledges fracturing at right angles to the plane of stratification into wedge shaped pieces; aside from this ledge, good stone can be had for all general uses.

Section at 'Possum Glory, Haw Creek Township.

Soil..	0 ft. 0 in.
Flagging stone, even bedded, No. 11, C. S.............	0 ft. 1 in.
Flagging stone, even bedded, No. 11, C. S.............	0 ft. 2 in.
Flagging stone, even bedded, No. 11, C. S.............	0 ft. 1 in.
Flagging stone, even bedded, No. 11, C. S.............	0 ft. 2 in.
Flagging stone, even bedded, No. 11, C. S.............	0 ft. 3 in.
Building stone, No. 11, C. S..................................	0 ft. 4 in.

Buliding stone, No. 11, C. S	0 ft. 5 in.
Building stone, No. 11, C. S	0 ft. 3 in.
Building stone, No. 11, C. S	0 ft. 4 in.
Building stone, No. 11, C. S	0 ft. 7 in.
Building stone, No. 11, C. S	0 ft. 4 in.
Building stone, No. 11, C. S	0 ft. 5 in.
Building stone, No. 11, C. S	0 ft. 6 in.
Building stone, No. 11, C. S	0 ft. 8 in.
Total	4 ft. 7 in

Here the stone has some whitish chert nodules, but is free from bands and can be quarried with the greatest facility. The top flagging members have a yellowish color that changes to a blue lower down in the bed. On the farm of Samuel Stroups, the flagging, fencing and light building stone is very fine. A deeper opening will doubtless develop thicker ledges and it would seem that Hope and vicinity, with a good pike to the quarry, should get their stone at this place. Excellent specimens of *Orthoceras annulatum* Sow., and *Gyroceras* were found in the upper strata. The calcareous shale outcrops in the vicinity, across the Decatur county line.

DEVONIAN AGE.

CORNIFEROUS PERIOD.

Corniferous Group.

The Corniferous group limestones form the surface stone and underlie the Drift of nearly the whole of the eastern upland portion of the county. It is the stone struck in digging wells in Rock Creek, Clifty, Clay and Haw Creek townships. It is the bed rock and stone exposed in the banks of Beaver creek, Little Sand creek, Duck creek, Otter creek, Haw creek, and their tributaries, and on top of the bluffs on Middle Fork, Fall Fork and Clifty creeks. From its lithological characters, we have divided it into three subdivisions, upper, middle and lower Corniferous. In relative thickness they stand in the proportion 10: 12: 40, but the outcrop in the county is not in the same ratio. The upper division, blue limestone, equivalent of the North Vernon quarry stone, was seen at but three places; James Manley's limekiln or Little Sand creek, and at the Everrode and Yaley quarries in Clay township. In thickness it is variable; at Manley's kiln it does not exceed three feet, and at the other outcrops scarcely reaches ten feet. The middle division is only found in force on Little Sand creek; other exposures of thin plates were seen on the bluffs east of Robert Ketner's place in the road from Hartsville to David Anderson's mill, and at John E. Robbin's farm. The lower member near Hope has a much greater surface exposure and thickness from having been protected by the others from the general denudation to which they have been subjected.

In lithological characters the upper Corniferous, North Vernon stone, is a hard, sometimes refractory, dark blue crystalline, massive, even bedded, magnesian limestone, of uniform structure that weathers well. The middle is a light blue, crystalline massive or thin bedded, shelly magnesian limestone, of variable structure, banded and mixed with amorphous chert-geodes and weathers to thin plates and shelly fragments. The lower Corniferous is a grayish, dark, dirty colored rock, never truly crystalline to the unaided eye, but showing, under a magnifier, very fine sand like specks, massive or thin, even bedded limestone of tolerably uniform structure, except where mixed with or replaced by chert or pockets of calcite, that weathers into large angular blocks and rotten stone. At many points the lower division might be termed a true argillaceous limestone and is everywhere mixed with a considerable per cent of alumina, and the manner in which it resists the action of water, and atmospheric influence is variable; where covered by a thin soil or kept damp the outside crust is a dirty rotten stone in appearance like sand, that tested with mineral acids and the microscope is found to be free from silex, at other places where exposed to air and rains alone, the face of the bluffs and detached block are eroded into holes and crannies, as if long subjected to the action of waves and running water. That such has been the case seems probable from many of the blocks standing alone and away from the adjoining bed rock. On the west side of Clifty creek north of John Graham's land are isolated masses with perpendicular fronts that measure from 19 to 26 feet in height. On the outside these blocks and bluffs present to the eye a hard, gray, or bluish appearance in contrast with the soft and lighter colored interior. On the north side of

Hiner's branch, a hundred yards or more above the mouth, the lower division limestone is replaced by a coral reef in which the fossils are not only silicified, but are imbedded in a silicious matrix, the counterpart of what is mentioned by Professor Borden, in his report on Jennings County, as a buhr stone, locally called "millstone grit," from its very great resemblance to genuine French buhr. Whether the bed reaches down to the top of the Niagara group stone it was impossible to tell as the lower part was covered, but that such is the case, is probable. The cellular buhr stone was seen at a number of places, and is doubtless peculiar to the lower division of the Corniferous group. At the base of the Corniferous, overlying the calcareous shale or Niagara limestone, frequently occurs hard, refractory, ochery-colored stone, that in appearance and lithological characters is identical with the top strata of the Niagara, both are equally persistent, and one or both may not show in the outcrop. Careful testing with acid and examination with the microscope fails to detect the presence of silex in either.

All of the Corniferous group members are fossiliferous, especially the silicious cherty portion, in this last respect differing from the chert of the Niagara that seldom contains organic remains. Scattered all through the upper and middle divisions of the crystalline stone, fragments and occasional perfect specimens are found, and abundantly, in the chert. We have not found any of the Brachiopods and only one Conchifer, *Conocardium trigonale*, H., that is common, and seems to be peculiar to the lower Corniferous division. At many places a part of the corals are replaced by calcite, but as a rule the stony frame work of carbonate of lime has been replaced by silex, hard and durable as the everlasting hills, that, resisting the weathering process, are found mixed in the glacial clay and gravel, and scattered over the soil; geological records and monuments that have been torn from their settings, all that remains of the once massive stone that has yielded to the ravages of time. From the short time given to the study it is not yet possible to say with certainty what fossils are peculiar to each of the divisions, but enough is known to indicate in a general way the range of some of the more common species. No perfect specimens of crinoids could be had, but fragments of the base are not uncommon, and huge stems, some of them very singular in having prolongations, wings, growing from every fourth or fifth ossicle, are abundant and found only in the upper blue limestone. The fragments of crinoids are referred to the genera *Megistocrinus*, *Synbathocrinus* and *Rhodocrinus*; *Dalmanites ohionensis*, Meek, was found only in these beds. The various species of *Strophodonta* have a wider range through all the upper and middle strata. Probably the lower division is best characterized by the absence of all higher forms of life than the corals, except *Conocardium*, which is common in some places.

A general subsidence of the ocean level took place at the close of the Silurian age, and that the lower Coniferous was deposited from shallow water, more or less contaminated with impurities, seems evident from the per cent. of alumina contained in it; that it was a sea filled with coral reefs and islands is shown by the great beds of zoophites found in masses of so-called millstone grit; corals grow and form limestone only when they are in reach of the waves (Dana). The thin laminæ of stone seen on Haw creek and Duck creek near Hope are the result of gentle wave action. These conditions were somewhat changed near the close of the Corniferous epoch, there must have been a slight subsidence of the interior continent, an increase in depth and clearing of the water favorable to the growth of higher forms of life, and the formation of pure crystalline limestone.

Section at James Manley's Lime Kiln, Rock Creek Township.

Soil	00 ft. 00 in.
Black shale, equivalent of the Genessee shale, etc No. 6. C. S.	1 ft. 00 in.
Blue crystalline limestone, North Vernon stone, massive and even bedded, fossiliferous, upper division of the Corniferous group, No. 7. C. S.	2 ft. 6 in.
Light blue crystalline limestone middle division of the Corniferous group, massive, slightly irregular in bedding, with chert nodules, fossiliferous, No. 8, C. S.	9 ft. 2 in.
Light blue compact massive stone, fair quarry stone, No. 8, C. S.	2 ft. 00 in.
Gray heavy bedded stone, lower division of the Corniferous group, No. 9, C. S.	2 ft. 00 in.

Gray heavy bedded stone with geodes and *Favosites hemisphericus*, Y. & S., containing petroleum...	2 ft. 00 in.
To the bed of Little Sand creek.........................	4 ft. 00 in.
Total..	22 ft. 8 in.

The stone at this section is extensively quarried for making lime, and all the members are used except the top blue limestone ledge that might be made useful for heavy foundations, but will be found hard and rather refractory to work. The lime rock ledges occasionally contain nodules of chert that are rejected in breaking the stone for the kiln; where mixed with silex the stone runs and vitrifies when heated, coming out at the bottom in glass-like masses, frequently studded over with beautifully colored beads. But the most singular phenomenon is the occurrence of good shaped nodular coral masses of *Favosites hemisphericus*, Y. and S., imbeded in the stone just as they grew at the bottom of a shallow sea and holding in the cup-like cavity of the colony, sometimes as much as an ounce of petroleum, that many eminent authorities think has been the result of the decomposition of the animal matter with which the living coral was charged. Aside from this no other evidence of bituminous matter was seen. At the bluff, south of the so-called Indiana mound, the middle Corniferous limestone has a thickness of from ten to twelve feet, very shelly in bedding, with quite an accumulation of talus at the foot, showing that it is a rock that will not successfully resist the vicissitudes of climate. As the dip of the strata to the west is but little greater than the fall of the creek, its banks show the same outcrop from Burnsville to the Manley lime kiln, except that the Black shale and blue limestone are not seen east of the road crossing Little Sand creek, Sec. 5, T. 9 N., R. 6 E. The creek cuts through the light blue fossiliferous limestone, and reaches the lower division of Corniferous group, near the residence of Dr. McLeod. It has already been mentioned that only a few plates of the middle Corniferous are to be seen in Clifty and Haw Creek townships, but the lower division, as may be seen from some of the sections given under the local details of the Niagara group, is thick and massive, but not of sufficient variety in structure to demand further notice. We may, in passing, remark that by the weathering of the soft stone at many points where exposed by the Drift, quantities of fossiliferous chert are found covering and imbedded in the soil.

Section at Mrs. R. Miller's Quarry, Haw Creek Township.

Soil mixed with gravel	3 ft. 0 in.
Gray massive limestone, lower division of the Corniferous group, in ledges from four to ten inches thick	8 ft. 0 in.
Soft gray stone in thicker ledges, No. 9, C. S.	2 ft. 9 in.
Gray stone in ledges from one to four inches thick, harder portions breaking into wedge-shaped pieces, No. 9, C. S.	4 ft. 0 in.
Gray limestone, weathering in places to a bluish color, No. 9, C. S.	4 ft. 0 in.
To bed of Duck creek	16 ft. 0 in.
Total	37 ft. 9 in.

Considerable quantities of stone have been quarried at this place, but it is not now worked. In bedding the stone is inclined to be irregular and does not break across the line of stratification with an even fracture, and aside from its not weathering well does not make a first class fencing stone, however, with some care in selecting and working, good stone may be had for light foundations and use where long durability is not a question.

Section on Duck Creek, John E. Robbin's Farm, Haw Creek Township.

Soil mixed with gravel	0 ft. 0 in.
Light blue fossiliferous limestone, middle division of the Corniferous group	0 ft. 11 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft. 7 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft. 3 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft. 4 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft. 3 in.

Gray limestone, lower division of the Corniferous group, irregular in bedding	0 ft. 10 in.
Gray limestone, lower division of the Corniferous group, irregular, in thin laminæ	3 ft. 4 in.
Gray limestone, lower division of the Corniferous group, massive, even bedded ledge	0 ft. 10 in.
Gray stone, thin ledges	1 ft. 6 in.
Soft gray stone in thin ledges not over one inch thick	2 ft. 8 in.
Gray massive stone, No. 9, C. S.	1 ft. 3 in.
To bed of Duck creek	10 ft. 0 in.
Total	21 ft. 11 in.

At this section was seen the most northern outcrop of the light blue limestone anywhere observed in the county. Here the stone contains a greater per cent. of alumina, and presents more the character of an argillaceous stone than at other points further south, but is free from shaly or clay partings.

Section at Robert Spaugh's Quarry, Haw Creek Township.

Soil, clay and gravel mixed	4 ft. 0 in.
Black soil, calcareous, with gravel	1 ft. 3 in.
Gray flagging stone, lower division of the Corniferous group, ranging from one to six inches in thickness	2 ft. 10 in.
Gray stone, even bedded No. 9, C. S.	0 ft. 8 in.
Gray stone, even bedded No. 9, C. S.	0 ft. 5 in.
Gray stone, even bedded No. 9, C. S.	0 ft. 7 in.
Gray stone, irregularly bedded	0 ft. 7 in.
Covered space to bed of Haw Creek	0 ft. 0 in.
Total	10 ft. 4 in.

Section at C. Deitrick's Quarry, Haw Creek Township.

Soil with gravel, lower part black and marly	3 ft. 0 in.
Weathered rotten stone, lower division of the Corniferous group, thin bedded	2 ft. 0 in.
Weathered rotten stone, lower division of the Corniferous group, more compact	0 ft. 5 in.

Gray stone, bedding regular, No. 9, C. S.	0 ft.	7 in.
Gray stone, bedding regular, No. 9, C. S.	0 ft.	6 in.
Gray stone, bedding regular, No. 9, C. S.	0 ft.	8 in.
Gray stone, bedding regular, No. 9, C. S.	0 ft.	9 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S	0 ft.	8 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S.	1 ft.	0 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S.	0 ft.	11 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S.	0 ft.	9 in.
To bed of Haw Creek, covered	0 ft.	0 in.
Total	11 ft.	3 in.

The stone at these places quarries in even blocks and is much more regular in bedding than at other points where sections of the lower Corniferous group have been taken. In structure it is non-crystalline to the naked eye, and not very compact, but seems to weather well. As a flagging stone it is superior, quite durable and when put down has much the appearance of a sandstone. It has been largely used in the pavements of Hope, and if selected would make the very best stone for that purpose, especially desirable on account of its soft structure breaking the sound of footsteps, so marked where the harder limestones are used.

When broken across, the stratum shows fine lines of lamination, more or less irregularly parallel with the stratification; where eroded by exposure the top and under sides of the stratum show nodular elevations and shallow depressions, as the result of the irregularity of the laminæ. It is evident that this stone was formed beneath the waters of a shallow sea and the lamination the result of wavelets, acting upon a fine sediment more or less mixed with alumina.

No fossils or signs of organic remains were seen, nor were any indications of chert noticed in any of the beds of the lower Corniferous where the four last sections were taken, but fragments of *Conocardium trigonale*, H., were seen in stone from a well in Hope.

Gray limestone, lower division of the Corniferous group, irregular in bedding	0 ft.	10 in.
Gray limestone, lower division of the Corniferous group, irregular, in thin laminæ	3 ft.	4 in.
Gray limestone, lower division of the Corniferous group, massive, even bedded ledge	0 ft.	10 in.
Gray stone, thin ledges	1 ft.	6 in.
Soft gray stone in thin ledges not over one inch thick	2 ft.	8 in.
Gray massive stone, No. 9, C. S.	1 ft.	3 in.
To bed of Duck creek	10 ft.	0 in.
Total	21 ft.	11 in.

At this section was seen the most northern outcrop of the light blue limestone anywhere observed in the county. Here the stone contains a greater per cent. of alumina, and presents more the character of an argillaceous stone than at other points further south, but is free from shaly or clay partings.

Section at Robert Spaugh's Quarry, Haw Creek Township.

Soil, clay and gravel mixed	4 ft.	0 in.
Black soil, calcareous, with gravel	1 ft.	3 in.
Gray flagging stone, lower division of the Corniferous group, ranging from one to six inches in thickness	2 ft.	10 in.
Gray stone, even bedded No. 9, C. S.	0 ft.	8 in.
Gray stone, even bedded No. 9, C. S.	0 ft.	5 in.
Gray stone, even bedded No. 9, C. S.	0 ft.	7 in.
Gray stone, irregularly bedded	0 ft.	7 in.
Covered space to bed of Haw Creek	0 ft.	0 in.
Total	10 ft.	4 in.

Section at C. Deitrick's Quarry, Haw Creek Township.

Soil with gravel, lower part black and marly	3 ft.	0 in.
Weathered rotten stone, lower division of the Corniferous group, thin bedded	2 ft.	0 in.
Weathered rotten stone, lower division of the Corniferous group, more compact	0 ft.	[illegible]

where offers of the powerful local action of some eroding agent, other than water alone; we have already shown that agent was doubtless *ice*.

Section at Arbuckle's Lime Kiln, Haw Creek Township.

Soil and covered space	0 ft.	0 in.
Weathered gray stone, lower division of the Corniferous group, massive and even bedded, quarried and used for burning to lime	1 ft.	4 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	4 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	1 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime	1 ft.	8 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime, with calcite and corals	2 ft.	10 in.
Weathered gray stone, lower division of the Corniferous group, massive and even-bedded, quarried and used for burning to lime with calcite and corals	0 ft.	10 in.
Covered space, place of the calcareous shale that shows as yellowish calcareous clay in the south bank of the quarry, No. 10, C. S.	3 ft.	0 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	1 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	2 in.
Flagging ochery colored on the outside, Niagara group	0 ft.	2 in.
Blue building stone	0 ft.	9 in.
Blue building stone with chert band	1 ft.	2 in.
Blue building stone homogeneous	0 ft.	10 in.
Blue building stone homogeneous	0 ft.	10 in.
Total	13 ft.	9 in.

The weathered members of the Corniferous are here true rotten stones of a dirty earthy appearance, in which many of the corals are replaced by calcite, especially in the lower beds. The whole out-crop above the calcareous clay, is soft, easily quarried, and makes a most excellent lime. The Niagara building stone is a beautiful blue heavy stone, apparently very even in structure. Across the creek is a bold escarpment of "cliff-rock," Niagara group below, and Corniferous above, from which a little stone has been quarried.

On the east bank of Clifty creek just below the mouth of Hiner's branch is an out-crop that shows the finest flagging any where seen, great yellowish slabs, smooth as a board, of any desirable thickness.

Section at Stucker Hole, Clifty Creek, Haw Creek Township.

Soil and covered space to top of the bluff, estimated..	30 ft.	0 in.
Lower division of the corniferous group, weathered soft, massive stone, fossiliferous........................	6 ft.	0 in.
Calcareous shale No. 10, C. S., highly fossiliferous at the base and upper end of the outcrop.........	4 ft.	0 in.
Blue Niagara group limestone, in ledges ranging from one to four inches in thickness to bed of the creek..	2 ft.	0 in.
Total..	42 ft.	0 in.

Above the Stucker hole good quarry stone can be had at many points, notably in a little ravine just above Critzer's mill. A peculiarity not noticed at other places was here seen, in one of the ledges fracturing at right angles to the plane of stratification into wedge shaped pieces; aside from this ledge, good stone can be had for all general uses.

Section at 'Possum Glory, Haw Creek Township.

Soil..	0 ft.	0 in.
Flagging stone, even bedded, No. 11, C. S..............	0 ft.	1 in.
Flagging stone, even bedded, No. 11, C. S..............	0 ft.	2 in.
Flagging stone, even bedded, No. 11, C. S..............	0 ft.	1 in.
Flagging stone, even bedded, No. 11, C. S..............	0 ft.	2 in.
Flagging stone, even bedded, No. 11, C. S..............	0 ft.	3 in.
Building stone, No. 11, C. S..................................	0 ft.	4 in.

Buliding stone, No. 11, C. S	0 ft.	5 in.
Building stone, No. 11, C. S	0 ft.	3 in.
Building stone, No. 11, C. S	0 ft.	4 in.
Building stone, No. 11, C. S	0 ft.	7 in.
Building stone, No. 11, C. S	0 ft.	4 in.
Building stone, No. 11, C. S	0 ft.	5 in.
Building stone, No. 11, C. S	0 ft.	6 in.
Building stone, No. 11, C. S	0 ft.	8 in.
Total	4 ft.	7 in.

Here the stone has some whitish chert nodules, but is free from bands and can be quarried with the greatest facility. The top flagging members have a yellowish color that changes to a blue lower down in the bed. On the farm of Samuel Stroups, the flagging, fencing and light building stone is very fine. A deeper opening will doubtless develop thicker ledges and it would seem that Hope and vicinity, with a good pike to the quarry, should get their stone at this place. Excellent specimens of *Orthoceras annulatum* Sow., and *Gyroceras* were found in the upper strata. The calcareous shale outcrops in the vicinity, across the Decatur county line.

DEVONIAN AGE.

CORNIFEROUS PERIOD.

Corniferous Group.

The Corniferous group limestones form the surface stone and underlie the Drift of nearly the whole of the eastern upland portion of the county. It is the stone struck in digging wells in Rock Creek, Clifty, Clay and Haw Creek townships. It is the bed rock and stone exposed in the banks of Beaver creek, Little Sand creek, Duck creek, Otter creek, Haw creek, and their tributaries, and on top of the bluffs on Middle Fork, Fall Fork and Clifty creeks. From its lithological characters, we have divided it into three subdivisions, upper, middle and lower Corniferous. In relative thickness they stand in the proportion 10: 12: 40, but the outcrop in the county is not in the same ratio. The upper division, blue limestone, equivalent of the North Vernon quarry stone, was seen at but three places; James Manley's limekiln or Little Sand creek, and at the Everrode and Yaley quarries in Clay township. In thickness it is variable; at Manley's kiln it does not exceed three feet, and at the other outcrops scarcely reaches ten feet. The middle division is only found in force on Little Sand creek; other exposures of thin plates were seen on the bluffs east of Robert Ketner's place in the road from Hartsville to David Anderson's mill, and at John E. Robbin's farm. The lower member near Hope has a much greater surface exposure and thickness from having been protected by the others from the general denudation to which they have been subjected.

In lithological characters the upper Corniferous, North Vernon stone, is a hard, sometimes refractory, dark blue crystalline, massive, even bedded, magnesian limestone, of uniform structure that weathers well. The middle is a light blue, crystalline massive or thin bedded, shelly magnesian limestone, of variable structure, banded and mixed with amorphous chert-geodes and weathers to thin plates and shelly fragments. The lower Corniferous is a grayish, dark, dirty colored rock, never truly crystalline to the unaided eye, but showing, under a magnifier, very fine sand like specks, massive or thin, even bedded limestone of tolerably uniform structure, except where mixed with or replaced by chert or pockets of calcite, that weathers into large angular blocks and rotten stone. At many points the lower division might be termed a true argillaceous limestone and is everywhere mixed with a considerable per cent of alumina, and the manner in which it resists the action of water, and atmospheric influence is variable; where covered by a thin soil or kept damp the outside crust is a dirty rotten stone in appearance like sand, that tested with mineral acids and the microscope is found to be free from silex, at other places where exposed to air and rains alone, the face of the bluffs and detached block are eroded into holes and crannies, as if long subjected to the action of waves and running water. That such has been the case seems probable from many of the blocks standing alone and away from the adjoining bed rock. On the west side of Clifty creek north of John Graham's land are isolated masses with perpendicular fronts that measure from 19 to 26 feet in height. On the outside these blocks and bluffs present to the eye a hard, gray, or bluish appearance in contrast with the soft and lighter colored interior. On the north side of

Hiner's branch, a hundred yards or more above the mouth, the lower division limestone is replaced by a coral reef in which the fossils are not only silicified, but are imbedded in a silicious matrix, the counterpart of what is mentioned by Professor Borden, in his report on Jennings County, as a buhr stone, locally called "millstone grit," from its very great resemblance to genuine French buhr. Whether the bed reaches down to the top of the Niagara group stone it was impossible to tell as the lower part was covered, but that such is the case, is probable. The cellular buhr stone was seen at a number of places, and is doubtless peculiar to the lower division of the Corniferous group. At the base of the Corniferous, overlying the calcareous shale or Niagara limestone, frequently occurs hard, refractory, ochery-colored stone, that in appearance and lithological characters is identical with the top strata of the Niagara, both are equally persistent, and one or both may not show in the outcrop. Careful testing with acid and examination with the microscope fails to detect the presence of silex in either.

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Section at James Manley's Lime Kiln, Rock Creek Township.

Soil	00 ft. 00 in.
Black shale, equivalent of the Genessee shale, etc No. 6. C. S.	1 ft. 00 in.
Blue crystalline limestone, North Vernon stone, massive and even bedded, fossiliferous, upper division of the Corniferous group, No. 7. C. S.	2 ft. 6 in.
Light blue crystalline limestone middle division of the Corniferous group, massive, slightly irregular in bedding, with chert nodules, fossiliferous, No. 8, C. S.	9 ft. 2 in.
Light blue compact massive stone, fair quarry stone, No. 8, C. S.	2 ft. 00 in.
Gray heavy bedded stone, lower division of the Corniferous group, No. 9, C. S.	2 ft. 00 in.

Gray heavy bedded stone with geodes and *Favosites hemisphericus*, Y. & S., containing petroleum...	2 ft. 00 in.
To the bed of Little Sand creek........................	4 ft. 00 in.
Total..	22 ft. 8 in.

The stone at this section is extensively quarried for making lime, and all the members are used except the top blue limestone ledge that might be made useful for heavy foundations, but will be found hard and rather refractory to work. The lime rock ledges occasionally contain nodules of chert that are rejected in breaking the stone for the kiln; where mixed with silex the stone runs and vitrifies when heated, coming out at the bottom in glass-like masses, frequently studded over with beautifully colored beads. But the most singular phenomenon is the occurrence of good shaped nodular coral masses of *Favosites hemisphericus*, Y. and S., imbeded in the stone just as they grew at the bottom of a shallow sea and holding in the cup-like cavity of the colony, sometimes as much as an ounce of petroleum, that many eminent authorities think has been the result of the decomposition of the animal matter with which the living coral was charged. Aside from this no other evidence of bituminous matter was seen. At the bluff, south of the so-called Indiana mound, the middle Corniferous limestone has a thickness of from ten to twelve feet, very shelly in bedding, with quite an accumulation of talus at the foot, showing that it is a rock that will not successfully resist the vicissitudes of climate. As the dip of the strata to the west is but little greater than the fall of the creek, its banks show the same outcrop from Burnsville to the Manley lime kiln, except that the Black shale and blue limestone are not seen east of the road crossing Little Sand creek, Sec. 5, T. 9 N., R. 6 E. The creek cuts through the light blue fossiliferous limestone, and reaches the lower division of Corniferous group, near the residence of Dr. McLeod. It has already been mentioned that only a few plates of the middle Corniferous are to be seen in Clifty and Haw Creek townships, but the lower division, as may be seen from some of the sections given under the local details of the Niagara group, is thick and massive, but not of sufficient variety in structure to demand further notice. We may, in passing, remark that by the weathering of the soft stone at many points where exposed by the Drift, quantities of fossiliferous chert are found covering and imbedded in the soil.

Section at Mrs. R. Miller's Quarry, Haw Creek Township.

Soil mixed with gravel	3 ft.	0 in.
Gray massive limestone, lower division of the Corniferous group, in ledges from four to ten inches thick	8 ft.	0 in.
Soft gray stone in thicker ledges, No. 9, C. S.	2 ft.	9 in.
Gray stone in ledges from one to four inches thick, harder portions breaking into wedge-shaped pieces, No. 9, C. S.	4 ft.	0 in.
Gray limestone, weathering in places to a bluish color, No. 9, C. S.	4 ft.	0 in.
To bed of Duck creek	16 ft.	0 in.
Total	37 ft.	9 in.

Considerable quantities of stone have been quarried at this place, but it is not now worked. In bedding the stone is inclined to be irregular and does not break across the line of stratification with an even fracture, and aside from its not weathering well does not make a first class fencing stone, however, with some care in selecting and working, good stone may be had for light foundations and use where long durability is not a question.

Section on Duck Creek, John E. Robbin's Farm, Haw Creek Township.

Soil mixed with gravel	0 ft.	0 in.
Light blue fossiliferous limestone, middle division of the Corniferous group	0 ft.	11 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft.	7 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft.	3 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft.	4 in.
Gray limestone, lower division of the Corniferous group, even bedded	0 ft.	3 in.

Gray limestone, lower division of the Corniferous group, irregular in bedding	0 ft.	10 in.
Gray limestone, lower division of the Corniferous group, irregular, in thin laminæ	3 ft.	4 in.
Gray limestone, lower division of the Corniferous group, massive, even bedded ledge	0 ft.	10 in.
Gray stone, thin ledges	1 ft.	6 in.
Soft gray stone in thin ledges not over one inch thick	2 ft.	8 in.
Gray massive stone, No. 9, C. S	1 ft.	3 in.
To bed of Duck creek	10 ft.	0 in.
Total	21 ft.	11 in.

At this section was seen the most northern outcrop of the light blue limestone anywhere observed in the county. Here the stone contains a greater per cent. of alumina, and presents more the character of an argillaceous stone than at other points further south, but is free from shaly or clay partings.

Section at Robert Spaugh's Quarry, Haw Creek Township.

Soil, clay and gravel mixed	4 ft.	0 in.
Black soil, calcareous, with gravel	1 ft.	3 in.
Gray flagging stone, lower division of the Corniferous group, ranging from one to six inches in thickness	2 ft.	10 in.
Gray stone, even bedded No. 9, C. S	0 ft.	8 in.
Gray stone, even bedded No. 9, C. S	0 ft.	5 in.
Gray stone, even bedded No. 9, C. S	0 ft.	7 in.
Gray stone, irregularly bedded	0 ft.	7 in.
Covered space to bed of Haw Creek	0 ft.	0 in.
Total	10 ft.	4 in.

Section at C. Deitrick's Quarry, Haw Creek Township.

Soil with gravel, lower part black and marly	3 ft.	0 in.
Weathered rotten stone, lower division of the Corniferous group, thin bedded	2 ft.	0 in.
Weathered rotten stone, lower division of the Corniferous group, more compact	0 ft.	5 in.

Gray stone, bedding regular, No. 9, C. S	0 ft.	7 in.
Gray stone, bedding regular, No. 9, C. S	0 ft.	6 in.
Gray stone, bedding regular, No. 9, C. S	0 ft.	8 in.
Gray stone, bedding regular, No. 9, C. S	0 ft.	9 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S	0 ft.	8 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S.	1 ft.	0 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S	0 ft.	11 in.
Darker gray stone, slightly irregular in bedding, No. 9, C. S	0 ft.	9 in.
To bed of Haw Creek, covered	0 ft.	0 in.
Total	11 ft.	3 in.

The stone at these places quarries in even blocks and is much more regular in bedding than at other points where sections of the lower Corniferous group have been taken. In structure it is non-crystalline to the naked eye, and not very compact, but seems to weather well. As a flagging stone it is superior, quite durable and when put down has much the appearance of a sandstone. It has been largely used in the pavements of Hope, and if selected would make the very best stone for that purpose, especially desirable on account of its soft structure breaking the sound of footsteps, so marked where the harder limestones are used.

When broken across, the stratum shows fine lines of lamination, more or less irregularly parallel with the stratification; where eroded by exposure the top and under sides of the stratum show nodular elevations and shallow depressions, as the result of the irregularity of the laminæ. It is evident that this stone was formed beneath the waters of a shallow sea and the lamination the result of wavelets, acting upon a fine sediment more or less mixed with alumina.

No fossils or signs of organic remains were seen, nor were any indications of chert noticed in any of the beds of the lower Corniferous where the four last sections were taken, but fragments of *Conocardium trigonale*, H., were seen in stone from a well in Hope.

Section of Jacob Everroad's Quarry, Clay Township.

Soil	0 ft.	0 in.
Genesee shale, Hamilton period	3 ft.	0 in.
Blue crystalline limestone, upper division of the Corniferous group, the equivalent of the North Vernon stone, massive, even bedded, in ledges from six to fifteen inches thick, fossiliferous, good quarry stone	3 ft.	5 in.
Blue crystalline limestone, No. 7, C. S., varying slightly in color, good quarry stone, fossiliferous.	1 ft.	3 in.
Blue crystalline limestone, No. 7, C. S., hard and compact, good quarry stone, and covered space to chert bed	3 ft.	6 in.
Chert bed, middle division of the Corniferous, not measured	0 ft.	0 in.
Total	11 ft.	2 in.

Section at John Yealy's Quarry, Clay Township.

Soil	0 ft.	0 in.
Black shale, Genesee, much weathered and discolored when exposed	2 ft.	6 in.
Blue crystalline, massive, compact, quarry limestone, upper division of the Corniferous group, fossiliferous	1 ft.	0 in.
Blue crystalline limestone, good quarry stone, fossiliferous, No. 7, C. S	1 ft.	3 in.
Blue quarry stone, No. 7, C. S., to the bottom of ravine on the east	4 ft.	0 in.
Total	8 ft.	9 in.

These quarries are near each other in the northeast corner of the township, and, as may be seen from the sections above, are much alike in the quality of the stone quarried. While considerable quantities of stone have been taken out, neither one has been worked to the bottom of the upper division of the Corniferous, and it is only an approximation made by estimate when we give the thickness of the whole at nine or ten feet, there is but little doubt, however, that this estimate, measuring from the chert bed to the black shale, is below rather than over the average. The stone for the foundation of the old Columbus court house, and that used in building the piers of the Clifty bridge at Newbern, came from here. The stone quarries in thick smooth slabs that break with an even square fracture, but does not split so well, except where natural seams exist. As for durability and power to resist pressure, it can not be excelled by any limestone in the west.

Some of the ledges, especially on the top of the stratum, are covered with fossils, but on account of the compactness of the martrix are very hard to get out in anything like a good condition, and through the mass of the stone fragments are not infrequent. The most common fossils are *Spirifera acuminata*, Conrad, *S. mucronata*, Conrad, *Strophodonta hemispherica*, H., *S. demissa*, H., an undetermined species of *Murchisonia*, and the calyces of *Megistocrinus* and *Synbathocrinus*, together with the pygidium of *Proetus planimarginatus*, Meek, and of *Dalmanites ohioensis*, M. The abundance of large and peculiar crinoid stems show that that form of animal life was once common.

HAMILTON PERIOD.

Black Shale, Genesee Epoch.

The stone of this epoch is locally known as black slate, but as it is slate only in appearance, we use the better term *shale.* It is the equivalent of the New Albany and Louisville black slate; Delphi, Ind., black slate; Huron shale of Ohio; Devonian black shale of the west; Genesee shale of New York, and the authors generally.

The eastern boundary of the outcrop is defined by the exposures in the banks of Little Sand creek, one mile east of James Manley's lime kiln, at the Yealy and Everroad quarries in Clay township, at the Manley lime kiln, and at the old saw mill near the residence of Martha Russell, in Rock Creek township. At the latter place the dip has gained on the base of the creek, so that the shale forms the bed of the stream. It is reported to have been struck in digging a saw mill well south of Elizabethtown, and in a well at Petersville. West of these points no outcrop is seen till it is exposed by the bed of White river at the Valley mills west of Taylorsville, and down the river to the Catfish falls below Lowell mills. The black shale was found and penetrated to a depth of thirty-one feet in digging a well at Krusee's garden in West Columbus.

The shale, where protected or unaltered by contact with the underlying rock, is a jet black stone, where exposed and weathered changing to lighter shades and splitting into thin foliaceous scales and plates. Imbedded in it, at the outcrop on White river are frequent nodules and masses of iron pyrites, ferrum sulphide, that rust and combine with the oxygen of the atmosphere. When quarried in large blocks they soon break and slack, the line of fracture being as often across the lamination as with it. It is said to contain ten or more per cent. of bituminous matter and by distillation to yield from ten to twenty gallons of oil to the ton. Taking the per cent. of organic matter at ten, the beds of this county contain enough bitumen to form a coal seam seven feet thick. Thrown on a fire it burns for a few minutes like stone coal, but the bulk of stone never grows less, the oily matters is burned out, leaving the earthy residue undiminished and not a true ash. From this many persons are led to think that deeper in the hill or by boring, coal might be found, aside from geological evidence; frequent borings show that this is not the case; it is not even a sign of coal. Attempts have been made to utilize it, and at one time great hopes were had of its being useful as a roofing material, spread on felt, but expensive trials made by grinding it at Lowell mills, in this county, and at New Albany, proved financially disastrous to the experimenters. It has been recommended as a road material, but its tendency to slack will preclude its use for this purpose. If of any practical value, other than as a part of the great mass of rocks necessary to the formation of the crust of the earth, we have not heard of it. In this age of cheap petroleum its distillation can not be made profitable.

The black shale at points south of this county, and especially in Ohio has been found to be fossiliferous. Nothing of the kind has been found by us, but may be, as large masses of hard rock, probably limestone, are reported, that frequently contain remains of fish.

While the crystalline limestone strata of the latter part of the Corniferous epoch teach us that they were formed under deeper and purer waters than had prevailed earlier, the great thickness of the black shale, stratification and homogeneity of structure, all point to its formation under shallow seas of impure water, conditions favorable to the deposition of sediment mixed with mud, and that these conditions were unchanged for a long period.

The question as to the origin of the bituminous matter can not be satisfactorily answered, but the paucity of the lower forms of vegetable life that had as yet come into existence and limited extent of dry land, would seem to show that it was derived from the organic remains so common in the preceding epoch, and not wholly wanting in this.

During the oil excitement, some years ago, Mr. C. C. Anderson sunk a well at the Valley mills on White river, and Mr. I. N. Smock, Trustee of German township, who lives in the immediate vicinity of the bore, has kindly furnished a record of the strata passed through. The section is given in Mr. Smock's own language, our comments in parentheses.

C. C. Anderson Bore, Valley Mills, German Township.

Earth (first river bottom)	10 ft.	0 in.
Slate (black shale, Genesee epoch)	40 ft.	0 in.
Appearance of coal (soot bed)	2 ft.	0 in.
Soft stone of same kind (black shale) of lighter color	18 ft.	0 in.
Stone resembling soapstone (black shale)	10 ft.	0 in.
Hard rock, upper division of Corniferous group	2 ft.	0 in.
Total	82 ft.	0 in

Deducting ten feet of earth and two feet of hard rock, we have seventy feet as the thickness of the black shale, which, compared with the estimated thickness from dip and bores made by Dr. Arwine and others, in Brown county, we think the measurement rather below than above the maximum. The presence of the base of the Knobstone series resting directly on the shale below Catharine's creek show that the deposit in this vicinity has not been much reduced by erosion. If borings are ever made in the southwest part of the county it will doubtless be found to increase in thickness, as most of our formations outcrop in greater force on the south.

We decide that "the stone resembling soapstone," is black shale mainly from stratigraphical position. No other than the black shale has been reported as occurring anywhere in the State, between the Corniferous limestone and Knobstone group.

The persistence of the "appearance of coal," at this bore, and at both bores in Brown county, the "soot" of the latter, and the occurrence of a soft black stone that could not be "picked" at the bottom of Krusees' well in West Columbus, at a depth of thirty-one feet, point to the conclusion that the black shale may be divided into two divisions, and that each of these may be of a different epoch, having fossils peculiar to each.

CARBONIFEROUS AGE.

SUB-CARBONIFEROUS PERIOD.

Knobstone Group or Epoch.

Many obstacles are met in trying to get a connected view of the sandstones and shales of this group, as the great mass of the rocks are covered by detritus and soil on the hillsides, and the clay banks of the creeks and tributary branches never expose the stone so far as we saw, but by repeated measurements where an opportunity offered and the lithological characters of the strata, enough is known to determine the general averages with a good degree of accuracy.

At Catfish falls, between Columbus and Lowell Mills on White river, the blueish gray calcareous shale, the equivalent of the Rockford Goniatite bed, has a vertical exposure of a few inches. The outcrop is fossiliferous and shows in thin even bedded, smooth homogeneous stones with a fracture at right angles to the bedding.

The blue aluminous shale, the equivalent of the New Providence shale of Prof. Borden, the next member of the Knobstone group in ascending order, has a thickness ranging from twenty-five to eighty-five feet. It is locally known as a soapstone, and is the underlying stone of the whole of Jackson township and the low hills of Wayne, Ohio, Harrison, Union and Nineveh, between the Wall ridge and the White river bottoms.

In structure, the blue shale is tolerable uniform, with a tendency to become ferruginous, near the base. In places it resists the action of the atmosphere and water better than the higher drab colored shales. Where weathered it forms a blue plastic clay, and cold subsoil.

Section at Noble Hill, Jackson Township.

Soil and covered space	40 ft.	0 in.
Blue shale, Knobstone group No. 5, C. S.	5 ft.	0 in.
Blue shale and iron ore nodules	5 ft.	0 in.
Blue shale to foot of the hill No. 5, C. S.	10 ft.	0 in.
Total	60 ft.	0 in.

This hill is said to be highest above the average level of any in the township. The iron ore nodules of this section were in good shaped masses that readily shelled and broke under the hammer, but in amount were insufficient to be of any practical value.

The other shales and the sandstones of Knobstone group are very variable in both vertical and transverse section, ranging from a blue to a drab, from argillaceous to silicious, from friable, coarse sandstone banded with iron ore to smooth homogeneous even bedded quarry stone. It is evident they were formed on the eastern shore and bed of an ocean generally quiet, whose currents came from the north or northeast burdened with sand and muddy sediment, derived from the wasting disintegration of some other land than the non-silicious limestones of the Devonian and Silurian ages of Indiana. The changing, fitful currents of this epoch that left sand at one time, and mud at another, and, again, both mixed together, were not favorable to the preservation of fossil remains, even if marine life existed to any extent under such conditions.

Section at Taylor Hill, Harrison Township.

Soil	0 ft.
Sandstone, coarse textured, with shaley partings and covered spaces, No. 1, C. S.	75 ft.
Sandstone, light colored, even bedded quarry stone, No. 2, C. S.	40 ft.
Shale, in thin beds and covered space, No. 3, C. S.	50 ft.
Iron ore, shale and sandstone, No. 4, C. S.	90 ft.
Blue shale, No. 5, C. S.	85 ft.
To level of Columbus court house	20 ft.
Total	360 ft.

The outcrop of the quarry stone at Taylor Hill has not been worked sufficiently to develop the true character of the rock, but enough has been taken out to show that it is a beautiful even freestone, with a square sharp angled fracture, and will split well. Whether this range of stone is the exact geological equivalent of the celebrated Berea grit and flagging of Ohio or not, it is found in the same geological group, and both were formed under similar if not identical conditions, and it should be fully developed. If once put on sale in quantities the demand for it would soon grow; it is a superior stone for many architectural purposes. Unlike many sandstones it does not retain dampness and become moss-grown. The exact equivalent of this bed has been extensively used in Brown county, and has been found a durable stone that withstands heat and cold. Monuments and tombstones cut from it forty years ago show sharp corners and chisel marks untarnished by the ravages of time. It is not the province of a geological survey to open coal mines or develop stone quarries, but to point out where capital may be invested with the prospect of a fair return for time and money expended; a reasonable experiment in opening the quarry sandstone of the Wall ridge, and putting the stone in shape for use would certainly prove a financial success. For water tables, window sill and caps, the rapid growth of Columbus and demands of the surrounding country would furnish a good local market. It is a persistent bed, outcropping on all sides of the Wall ridge. Great blocks were seen on the south and north in crossing the ridge from John Ault's place to Bethany. The Dowell hill quarries are in the same range and show the same stone. Mr. M. Powell, near the Brown county line, has eighty acres of quarry that can be worked at almost any point. To multiply outcrops would be to give a list of the land owners of nearly the whole west half of Harrison township.

Section at Henry Grass' Quarry, Harrison Township.

Soil free from gravel	1 ft.	0 in.
Shale and sandstone in thin beds and wedge-shaped masses, Knobstone group, No. 1, C. S.	7 ft.	0 in.
Sandstone banded with iron ore, No. 1, C. S., irregularly bedded	1 ft.	1 in.
Sandstone, even bedded, No. 2, C. S	1 ft.	7 in.
Massive sandstone in an even, continuous bed, without any indication of horizontal seams or partings, No. 2, C. S	2 ft.	9 in.

Thin drab shales, No. 3, C. S	50 ft.	00 in.
Shale and iron ore No. 4, C. S	87 ft.	00 in.
Blue aluminous shale No. 5, C. S	47 ft.	00 in.
Total	185 ft.	5 in.

This section embraces 42 feet of blue shale and reaches to a level with Mr. Grass' residence; to the bed of Wolf creek would add 35 feet more. The two feet nine inches stratum is a rather coarse grained dark sodden looking stone that is worked mainly for foundations, and is remarkable for uniformity of structure and evenness of bedding for the whole length of the quarry.

HARTSVILLE FOSSILS.

As no attempt was made in the body of this report to give a list, even of the more common fossils of the calcareous shale, the following is here inserted and embraces all the species, except Bryozoa, that have been identified. An examination will show that it compares very favorably with the celebrated and well known Waldron locality.

List of Calcareous Shale Fossils.

(Found near Hartsville, Ind.)

PROTOZOA.

Receptaculites subturbinatus, H., rare.
Astylospongia præmorsa, Goldf., not rare.

CORALS AND BRYOZOA.

Streptelasma radicans, H., rare.
borealis, H., not rare.
Favosites spinigerus, H., not rare.
forbesi var. *occidentalis*, H., common.
Lichenalia concentrica, H., common.

CRINOIDEA.

Saccocrinus christyi, H., not rare.
Macrostylocrinus striatus, H., rare.
fasciatus, H., rare.
Glyptocrinus carleyi, H., rare.

Glyptaster occidentalis, H., rare.
inornatus, H., not rare.
Codaster pulchellus, M. and D., rare.
Cyathocrinus polyxo, H., rare.
nucleus, H., rare.
Lecanocrinus pusillus, H., rare.
Melocrinus (ined), not rare.
Rhodocrinus melissa, H., common.
Eucalyptocrinus crassus, H., common.
cælatus H., common.
ovatus, Troost, rare.
Stephanocrinus gemmiformis, H., very rare.

BRACHIOPODA.

Crania siluriana, H., rare.
setifera, H., rare.
Orthis hybrida, Sowerby, not rare.
elegantula, Dalman, not rare.
Streptorhynchus subplana, Conrad, not rare.
Strophomena rhomboidalis, Wahlenberg, not rare.
Strophonella semifasciata, H., very rare.
Spirifera eudora, H., rare.
crispa, Hisinger, common.
crispa var. *simplex*, H., rare.
radiata, Sowerby, common.
waldronensis, M. and D., rare.
Meristina maria, H., common.
nitida, H., very common.
Nucleospira pisiformis, H., rare.
Retzia evax, H., very common.
Atrypa reticularis, Linn, very common.
Rhynchonella neglecta, H., not rare.
acinus, H., not rare.
Rhynchonella indianensis, H., common.
whitii, H., very common.
stricklandi, Sowerby, not rare.
cuneata, H., common.
Anastrophia internascens, H., common.
Eichwaldia reticulata, H., not rare.

LAMELLIBRANCHIATA.

Pterinea brisa, H., very rare.
Modiolopsis subalata, H.

GASTEROPODA.

Platyostoma niagarense, H., common.
plebium, H., not common.
Strophostylus cyclostomus, H., common.
var. *disjunctus*, H., not common.

CEPHALOPODA.

Orthoceras simulator, H., very rare.
Trochoceras waldronense, H., very rare.

ANNELIDA.

Cornulites proprius, H., not rare.

CRUSTACEA.

Calymene niagarensis, H., not rare.
Homalonotus delphinocephalus, Green., rare.
Cyphaspis christyi, H., rare.
Illænus armatus, H., rare.
Dalmanites vigilans, H., not rare.
verrucosus, H., not rare.
Lichas boltoni, var. *occidentalis*, H., rare.

All the above species were found on Clifty creek and tributaries, near Hartsville. Probably the best places for collecting are the Tarr Hole and Anderson's Falls. The north bank and bluffs of Little Sand creek, above Manly's limekiln, is the best place for getting corniferous group fossils; the corals are frequently very fine. The corals from the lower beds are found scattered over the fields and woods, mixed with the surface soil.

Among the corals found may be mentioned *Favosites favosus*, Gold., *F. hemisphericus*, Y. & S. *F. emmonsi*, Rom., *F. niagarensis*, H., *Michelinia trochiscus*, Rom., *Pleurodictyum problematicum*, *Cyathophyllum cornicula*, Rom., *C.*, *geniculatum*, Rom., *C. rugosum*, E. H., *C. davidsoni*, M. E., *C. radicula*, Rom., *Blothrophyllum decorticatum*, Billings, *Phillipsastrea verneuili*, M. E., *Zaphrentis gigantea*, Raff. *Z. compressa*, Rom., *Amplexus yandelli*, M. E., *Cysti-*

phyllum americanum, M. E. One single specimen of *Nucleocrinus angularis*, Lyon, was found at the same locality, and a few species of brachiopods.

ANTIQUITIES.

That the East White river valley was once inhabited by a race of people superior to the Delaware Indians, the last tribe to disappear before the " star of empire," is shown by the number of stone implements, axes, hatchets and fragments of pottery, found scattered over the soil. Some of these relics are very fine, especially a highly finished dark stone pipe in the shape of a bird's head and bill, owned by Mrs. Dr. George Remy, found near Newbern, and an oblong double, greenstone hatchet and flesher, found and owned by Mr. VanBlaricum, near Burnsville. A number of elevations are pointed out as the work of the mound-builders, but we failed, wherever they were examined, to find any of the so-called Indian mounds of any other than natural origin. The mound on the Hacker farm, just above the Manley limekiln, is clearly proven to be a part of the high bank north of Little Sand creek, by an excavation made in the side, that exposes the rock of the mound and shows it to be continuous with the strata of the adjoining bluff. The Indians' burial place on the farm of Mr. James C. Remy, near Burnsville, is a natural ridge of upland gravel. That the Judge Tunis Quick Mound, in Flat Rock township, is not artificial, has been indicated in the discussion of the Drift period. In structure it is identical with the Hawpatch gravel, and shows no evidence whatever of being the work of man. It is not a mound, but an irregular hill that slopes to the south. We did not have an opportunity to examine the Tipton hill in Columbus, but from what we could learn the same is true of it. Artificial mounds ought to show peculiarities in stratification different from that of the surrounding plain. The finding of bones only proves that advantage was taken of the higher points to locate a cemetery. Bones have been taken from the bluff between the junction of Clifty and Fall Fork creeks, from the Remy gravel bed, and the so-called Hacker mound, but nothing else, so far as we could ascertain. If, in opening these mounds, beds of ashes, buried soil, broken bones of animals, water jugs, pottery, pipes, beads or ornaments were found, the proof would be conclusive that they were the work of the extinct race of mound builders, but as only bones have been found, they are probably the "last resting places" of the modern Red man. In expressing the above opinion, we know we run counter to the traditions of the mass of the people, and if our adverse opinion shall be the means of inducing some one to hunt up the proof that our so-called mounds are artificial or the burial place of the mound builders, we shall be pleased and have done a good work.

ECONOMIC GEOLOGY.

AGRICULTURE AND SOIL.

Water, the great chemical solvent in its various forms of rain, dew, snow and ice, has been the principal agent in the formation of soil, together with the co-operation of heat, cold and other atmospheric influences. Besides being the principal force involved in the primary formation of soils, water has been the grand agent engaged in their comminution, mixing and distributing over the face of the barren rocks. But water and atmospheric influences alone, notwithstanding their chemical and mechanical power to change and build up the inorganic elements, could never make a productive soil. To secure fertility and give the potentialities of life to an otherwise inert mass of clay, sand and gravel, the organic must be added to the inorganic, the living must be added to the non-living. The early history of a productive soil begins with the earliest forms of life, those forms that mark the border line that distinguishes the animal from the plant. It matters not whether animal or plant, from the gray lichen to the monarch of the forest, from the tiny zoophyte to the leviathan, all furnish necessary and essential elements that cause the barren places to literally bloom as the rose. The product of these influences acting through countless ages, has given to Bartholomew county some of the most fertile lands in the great Interior Basin; will the farmer husband this heritage, or dissipate it by slovenly methods of working his land and non-rotation of crops. While the county can boast of some of the best, and most careful, scientific farming, much of the land is being rapidly exhausted. A soil once exhausted, can only be brought back to fertility at great cost, and at the expense of some other locality that must furnish the necessary organic matter, or else wait years for it to be renewed by the slow processes of nature.

For descriptive purposes the soils of the county may be divided with reference to their geological origin, into, (1) *Native*, those derived from decomposition of rocks found in place in parts of Ohio, Harrison and Union townships. (2) Terrace clay soil, derived in part from the knobstone shale, and in part from material deposited by water of the Terrace epoch, of Jackson township, and parts of Wayne, Ohio, Harison and Union. (3) *Terrace Sand* soil of Sand Creek and Wayne townships. (4) *Drift Gravel* soil, mainly of alluvial origin, of Flat Rock and Columbus townships. (5) *Alluvial* soil of the White river bottoms. (6) *Glacial* clay soil of Nineveh, German, Haw Creek, Clay, Clifty and Rock Creek townships.

The native soil of the Wall ridge is light and sandy, of a warm nature, supporting a splendid growth of timber; is not adapted to general agriculture, but is most excellent fruit land. The terrace clays are cold and sticky, but in favorable seasons excellent corn land. The terrace sand with its liberal admixture of calcareous matter is one of the best soils in the county, especially where mixed annually with organic matter of alluvial origin. The Haw-patch gravel soil, as mentioned above, is of alluvial origin, and the fact of its being of such origin should impress itself on every farmer living in that region, for once exhausted, nature will do but little to restore it, and artificial means be used with less benefit than on clay soils. The overflows and marshes that made the alluvial deposit ceased long ago, and will probably never recur again. The Haw-patch farmer has a bonanza, but like many other good things it may be wasted, and once wasted never regained.

The glacial clay soils, much the most general of any in the county, are in many parts or rather most places sticky and tenacious, retaining water and requiring under drainage. The importance of thorough drainage has been sufficiently demonstrated by what has been done, and in a few years will be made complete. This soil will last well and with average good care improve from year to year. Artificial means of improving and renewing can be applied with profit, as the top soil has a most excellent sub-soil that will return dollars for dimes invested.

TIMBER.

The primeval forest of the county was dense, much of it a magnificent growth that has fallen before the axe of civilization, so that a grand old poplar is now the exception. The timber of the Wall ridge is mainly the various species of oak, hickory and walnut with a dense undergrowth. The chestnut oak, *Quercus castanea*, is peculiar to the rich sandy soil of this region, and is in great demand for its valuable bark. By the present wasteful method of peeling the small trees and saplings the supply will soon be exhausted. The white oaks and yellow poplars *Liriodendron tulipifera*, are very fine. The timber of the White river bottoms is largely yellow poplar, white oak, black walnut, hickory, beech and splendid speciments of *Ulmus americana*, American elm, and sycamore, *Platanus occidentalis*. In the Hawpatch is found most of the trees peculiar to this latitude, and they are remarkable for their uniform size and height before putting out branches, giving to the forest the appearance of an improved woodland. The only form of undergrowth noticed was a species of hawthorn, *Cratœgus coccinea*, and it is from the presence of this thorn that the name, Haw-patch, is said to be derived. The vast majority of the timber of the glacial clay is beech, *Fagus feruginea*, interspersed with white oak, red oak, ash, walnut, poplar and patches of sugar maple and hickory. Dogwood, red bud and many other species of small trees, common further south, are rather rare. Sweet gum, *Liquidambar styraciflua*, occurs on the wet lands; paw-paw, *Asimina triloba*, in profusion in rich open woods; coffee nut, *Gymnocladus canadensis*, and *Tilia americana*, bass wood, along the streams; *Fraxinus viridis*, green ash; *Populus monilifera*, cottonwood, and several species of willow are not infrequently found.

Notwithstanding the immense amount of timber that has been destroyed and worked into lumber, saw mills are more common than at any previous time in the history of the county, and while many of the logs they cut are of hard wood, fine poplars, from the land of some careful farmer, are not infrequent. The finest lot of poplar was seen at the Waymansville mill.

MINERAL SPRINGS.

There are three noted chalybeate springs in the county, and many more of minor renown. The Azalia spring two miles north of town on Little Sand creek has the widest reputation, and might be made a very successful resort for invalids and pleasure seekers. It is surrounded by a magnificent growth of American elms and other forest trees that furnish a peculiarly delightful shade in the hot summer afternoons. The Hartsville spring, in the south part of the College campus, has acquired considerable repute in the last few years. The Anderson spring, just below the Anderson falls on Fall Fork creek in volume of water is vastly the superior of the others. All these springs are in a sense artesian, they all boil up from the depths below; that at Little Sand creek, through the sand, that at Anderson's through a fissure in the underlying limestone. The temperature of each is about 53° Fahr. They are nearly if not identical in composition and in no way sulphur springs and should not be called such. Roughly tested they were found to contain iron, magnesia and lime; the iron probably exists in combination as carbonate of the protoxide, and the lime and magnesia as bi-carbonates, the latter salts occuring in no greater quantity than is usually found in potable well and spring waters. They are in local repute as remedial in a number of diseases, and as they are pure chalybeate waters may be safely used with advantage where a mild preparation of iron is indicated.

BUILDING STONE.

Nothing is left to say under this head as to the quality of the stone found in the county. But few counties in the State are so favorably situated as this for getting a home supply of good stone. On the east along Clifty creek we have the Niagara group magnesian limestone of the same geological age and structure as the Greensburgh and St. Paul stone, in Clay township the equivalent of the North Vernon blue stone, and in the Wall ridge of the Knobstone a splendid freestone. Along Clifty creek quarries may be opened in numbers that will require very little stripping, and especially are the Everroad and Yealy quarries favorably located for working with ease.

FRUIT.

Apples, pears, cherries and other small fruits do well in all parts of the county. The extreme cold of last winter, 1880, '81, and drouth of the succeeding summer, was very hard on many orchards, but may be turned to advantage in determining what varieties will stand the climate best. Under drainage is needed in many orchards. The Knobstone hills are specially adapted to the growth of peaches and grapes. The warm, sandy hill soil showed its influence on the orchards last spring, in bringing the apple and peach trees out in full bright green leaf, while the trees on the lowlands were shriveled and many dying. Much might be done to improve the peach orchards by planting better varieties.

LIME AND SAND.

Mr. James Manley at his kiln on Little Sand creek, as has already been mentioned, uses the middle, light blue crystalline stone of the Corniferous group, and one or two ledges of the lower division for burning to lime. It makes a most excellent white lime, the small per cent. of alumina found in the stone adds to plastering qualities and gives it repute with the workmen for running on easily and smoothly. His kiln is a Page's patent, and has a capacity to turn out seventy-five barrels per day. Mr. Sam. Arbuckle runs two kilns near Hartsville, using the lower Corniferous stone, and making a good lime, for which he has a very ready sale at the kiln. In fact, all the Corniferous rocks are good stone for making the very best of lime.

The yellow bluff sand and washed creek sand stands at the top of the list for plasterers' and masons' use, and is found in abundance throughout the central and eastern parts of the county. The yellow bluff sand found near the Burnsville pike bridge is used for making moulds by the Messrs. Busch, founders, in the city of Columbus, and is found to fill the bill as a moulder's sand. Doubtless if brought to the attention of foundrymen at other points, a foreign demand would soon grow up.

BRICK CLAYS.

Brick clay may be found at almost any point where needed. In the county are five tile factories, a part of them using all the modern improvements in machinery and producing most excellent tile, for which there is a good local demand. Some years ago earthen ware was made at Hartsville, from clay found in the vicinity.

MANUFACTORIES.

The flouring and hominy mills of Gaff, Gent & Thomas, located at Columbus and Lowell, may be said to have a continental reputation; their productions have found a market in Europe. The Drybread Brothers, proprietors of the Valley Mills, west of Taylorsville, do a very large custom and merchant flouring business; the Lowell and Valley Mills are run by water power, the cheapest of all power. The American Starch works at Columbus, are among the most extensive in the country. To further enumerate would be to attempt a business list of Columbus. Those mentioned above are only the most extensive.

ROAD MATERIAL.

Gravel for Macadamizing can readily be had in German, Flat Rock, Haw Creek, Clay, Clifty, and some parts of Rock Creek township, and from the bars in White river. It has been proven by testing in actual use that it is not every bed of gravel that will wear well, even some of the rounded metamorphic stone gravel seems to be rotten and soon breaks down into dust. The clean, dry gravel of Flat Rock is typical of the best. Where the per cent. of limestone pebbles is large, especially if derived from the soft Corniferous rocks, besides rendering the mass uneven in size, it will not wear well.

WATER SUPPLY.

Modern sanitary science has demonstrated that many of our most dangerous diseases are spread and the poison that produces them are frequently introduced into the system by impure drinking water, and as the water supply of a country is largely dependent on its geological structure, a word on the subject may not be out of place. All over the county are many fine springs of most excellent water, but not in numbers to supply the general demand, hence wells are the main dependence. Of the advantages of using only a pure soft water, such as may be secured in large cisterns, nothing need be said only that their use should be made more general, and large enough to hold a summer supply. The wells dug in the glacial clay range from twenty to thirty feet in average depth and the water found most frequently in the underlying limestone, and afford a good hard water that may be considered free from dangerous contamination from surface drainage, where not sunk in low places as is frequently the case. Wells sunk in the gravel and sand are peculiarly liable from the very nature of the porous subsoil to become polluted, and should be so located as to avoid all danger of soakage from the kitchen, outbuildings or barn. The ease with which they may be poisoned will be apparent when we consider that the average depth of wells in the Hawpatch is about twenty feet, and in Sand Creek township from eighteen to twenty-two feet. Over a large part of the county, even in many places under and in the glacial clay, the water vein is found in the gravel. Such is the case in Sand Creek and Wayne townships, where the overlying soil is sand, and in German and Nineveh townships where the subsoil is clay. When inquiry was made as to the depth of wells, the answer almost invariably was, "We get water in the sand or gravel on a level with the river," and the general impression is that the supply comes from the river. That such is not the case above Columbus is apparent from the nature of the river bottom and banks, black shale and tenaceous clay, nor is it probable below the city. From railroad elevations we find that the bed of White river is thirty-four feet below the bridge at Columbus, and that the average depth of wells in the city fails to reach so low a level by twelve feet, and that wells have been sunk twenty-six feet below the river level before water was found, as at the McEwen well. Wells going below the river twenty feet are not uncommon. The explanation for the wide spread belief that the river level has to do with finding water, is found in the well-known fact that any bed of sand or gravel covered with clay is a water bearing stratum. Any experienced well or cistern digger will tell you that every little bed of sand passed seeps water.

EDUCATION.

Hartsville University, under the denominational control of the United Brethren in Christ (not Moravians), is located at Hartsville, and has a charter granting full University privileges and powers. Both sexes are admitted and are equally entitled to degrees on completion of the prescribed *curriculum*. "The course of study embraces the branches usually taught in such an institution East and West, and numbers among its graduates many worthy and prominent citizens of this and other counties and States." Parents and guardians who wish to place their children and wards at a good school, healthfully located in a town free from the vices and temptations of most larger places, can not do better than to consider the claims of this institution.

Moravian Seminary for Young Ladies, at Hope, "is a boarding school for young ladies, and is designed to afford, in the wholesome retirement of a rural neighborhood, and at a moderate cost the best opportunities for acquiring a thorough education. The institution has not been established for private advantage, but for public good. It is the property of the Synod of the Moravian Church in the Northern District of the United States, and is conducted on the plan and principles of the older and well known Moravian boarding schools in this country and Europe."

Central Conservatory of Music—This institution is located in the city of Columbus, in a building erected expressly for a musical academy, and is one of the most attractive buildings in the city. The class system of the conservatories of Europe is used. "The regular course of study is especially adapted to those desiring a complete and thorough education in music at the least expense and in the shortest possible time."

Columbus City Schools—Have, under the efficient management of Prof. Andrew Graham, assisted by an able board of trustees, taken rank with the best schools of the State. Graduates of the Columbus High School may well be proud of their *alma mater*.

THANKS.

In general we return thanks to all the citizens of the county whom we have met during the survey. For favors and information we are indebted to Lewis Donhost, county auditor, and James Wells, deputy; Messrs. Geo. Pence and Geo. W. Forester, of Columbus; Mr. James Manley, of Rock Creek township; Dr. Henry Connelly, of Elizabethtown; Messrs. John Myer and Frank Miller, of Waymansville; Dr. Smith, of Bethany; the Drybread Brothers, of the Valley Mills; Mr. I. N. Smock, of German township; Messrs. S. S. Ryker, M. F. Dawson, H. G. Chamberlain, Dr. Geo. Remy and G. Will. Brown, of Hartsville; Mr. Nathan Newsom, of Sand Creek township, and Miss Julia Miller, of Hope.

PALEONTOLOGY.

PALEONTOLOGY.

DESCRIPTIONS

OF THE

SPECIES OF FOSSILS FOUND IN THE NIAGARA GROUP

AT

WALDRON, INDIANA.

By PROF. JAMES HALL, State Geologist of New York.

THE FAUNA OF THE NIAGARA GROUP IN CENTRAL INDIANA.

The Waldron locality of the Niagara group, which has proved so prolific in species, and so abundant in the individuals of nearly all of them, was discovered in 1860 by Prof. David Christy, of Cincinnati, and the information was communicated to Prof. James Hall in the Autumn of that year. After a partial study of the collections of Prof. Christy, together with some other specimens furnished by several persons, and of subsequent, more extensive collections from the same locality, Professor Hall communicated to the Albany Institute, April 29, 1862, a "Notice of some new species of fossils, from a locality of the Niagara group in Indiana, with a list of identified species from the same place." This paper was published in Vol. IV of the Transactions, and an abstract of the same was published in pamphlet form in May, 1863.

Further study of these collections, together with additional material, enabled the author of these papers to prepare a more extended memoir, with figures of the greater portion of the species then known. The illustrations of these species in thirty-two octavo plates, were published in a documentary edition of the New York State Museum Report in 1876.

The text of the descriptions, together with the plates, was published in the Museum edition of the report in 1879. In the meantime additional, collections from the Waldron locality necessitated an additional paper, which was communicated to the Albany Institute, in March, 1879, entitled, "Descriptions of New Species of Fossils from the Niagara formation at Waldron, Indiana."

Within the past few years, new species from this locality, in addition to those published by Professor Hall have been described by Messrs. S. A. Miller and C. B. Dyer, and by Mr. U. P. James, which we may hope to see illustrated in a future report.

The species herein described and figured are all from a single locality on Conn's Creek, near the town of Waldron, Shelby county, Indiana, where the calcareous shales of the group, with thick seams of limestone occur. Many of the same species are found in more calcareous beds at the neighboring locality of St. Paul, in the same county, and also at localities further south on Conn's Creek, and in Bartholomew county.

The investigation has proved an interesting one, especially as an aid to our knowledge of the geographical distribution of the Niagara fauna.

In the Twentieth Report on the New York State Cabinet of Natural History, there is a pretty full illustration of the predominant forms of this fauna, as represented in the Niagara formation of Wisconsin, where the prevailing rock is a magnesian limestone. Dr. F. Roemer, in his "Silurische Fauna des Westlichen Tennessee," has given an illustration of the fauna of this period as known in that State. To these publications we may add Volume II of the Palæontology of New York, which illustrates the Niagara fauna in its typical locality, and we have thus the means of comparison between the prevailing forms of four widely separated regions.

Among the collections from Waldron, we find a greater proportion of species identical with those of New York than in any other western locality, while the new forms are of the same genera, and often quite nearly allied to those of the Niagara region. It is however a little remarkable, that while we have in the Indiana locality twice as many crinoidal species as in New York, and more than ten times as many individuals, there has not been found a single specimen of Caryocrinus, which is the most abundant form of crinoid in New York, also occurring quite frequently in Wisconsin and Iowa, and more abundant in Tennessee than in the other localities.

The physical conditions originally existing at Waldron were more similar to those of Western New York, than to those of any other region. In Wisconsin and Iowa the outcrops are chiefly of magnesian limestone, and the Gasteropoda and Cephalopoda predominate, while the Cystidæ are often equally conspicuous with the Crinoidea. At the Waldron locality, cystidean forms are extremely rare, and but few are known in Tennessee; and though not abundant in New York, more species are known there than at both the other localities named. It is probable, however, that in this comparison we are not dealing with the same beds in each one of these localities. While the prevailing fossiliferous beds in Western New York are essentially parallel with those of Waldron and of Western Tennessee, those of Wisconsin and Iowa are to a considerable extent somewhat older, being the lower beds of the series; while the others are of the newer and middle portion of the formation.*

It would appear, from what we know of the physical conditions of this ancient sea, that it was generally shallow and the bottom extremely uneven.

The Niagara group, in its eastern outcrop from Eastern New York to Virginia, indicates a nearly uniform shallow sea, with the deposition of calcareous beds of magnesian character, which, in their southwestern extension, become in part replaced by, or alternate with, argillaceous deposits. Along this line the formation is everywhere thin, and so inconspicuous that it has usually been considered a subordinate member of the succeeding group. It is here usually marked by the presence of a

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*The relations of the different members of the Niagara formation in Wisconsin, Iowa, and other western localities with those of New York, have not been fully determined. It is known that in Canada West (Ontario) the limestones of the lower part of the formation acquire a greatly increased thickness over the same beds in Western New York; and that they also include the Clinton limestones since they contain *Pentamerus oblongus* and some other Clinton forms of New York. In their western extension these limestones gradually lose their shaly partings and their seams and beds of shale, becoming massive and nearly uniformly ashen or drab in color. In this condition the mass is recognized as a part of the Niagara group, and the Clinton group is restricted to arenaceous and shaly beds, sometimes with thin calcareous bands, corresponding more nearly in physical characters with the same formation in Herkimer and Oneida counties, in the State of New York.

few species of corals which are extremely abundant, some forms of Brachiopods, a few Lamellibranchs, Gasteropods and Cephalopods, and, more rarely, some remains of Trilobites. These are indentical with or nearly allied to those which characterize the formation in its more western localities. Westerly, within the limits of New York, the formation has a very moderate development, until, at the eastern part of Wayne county, the shaly member becomes marked and gradually increases in thickness to Niagara county; and the superior limestone increases in thickness in the same direction.

The shaly fossiliferous beds, so conspicuous on the Genesee river at Rochester, in Wayne and Niagara counties, and upon the Niagara river, thin out greatly within fifty miles west of the river, and are nowhere seen along the outcrops in a westerly and northwesterly direction. This shaly member of the formation was apparently deposited in a wide, shallow depression in the bed of the ancient ocean, which became gradually filled with fine calcareous mud, and which, during this slow process, afforded opportunity for the development of a most abundant fauna.

In Indiana, also, these shaly beds were probably deposited in a wide depression of the ocean bed, similar to that of Western New York, while to the northward the area was a more shallow sea. We have a less accurate knowledge of the physical conditions prevailing to the south and southwest of the region described; but it would appear, from what we know of the distribution of the fossils, that there were similar areas of depression with a most abundant fauna, while the intermediate shallower areas are marked by the presence of calcareous deposits, with a moderate development of a somewhat distinct fauna, in which corals are usually conspicuous, and carrying the aspect of an interrupted and imperfectly developed coral reef.

PLANTÆ.

BUTHROTREPHIS, *Hall.*

BUTHROTREPHIS GRACILIS, var. CRASSA, *Hall.*

Plate 1, *Figs.* 6.

Buthrotrephis gracilis, var. *crassa*, HALL. Pal. N. Y., Vol. II, p. 19, 1852.

Plant flexuous, branching; branches simple or bifurcating, more or less diverging from the central stipe, obtuse at the extremities, often nodulose.

But few specimens of this species have been observed among the extensive collections which have been examined. They are somewhat coarser in their manner of growth than *B. gracilis* proper, agreeing in this particular with the variety *crassa.* In its general characters, this species resembles *B. subnodosa* of the Hudson river group; but it is usually more delicate in form, and differs in its mode of branching and in the form of the branches which in that species are always somewhat nodulose.

PROTOZOA.

RECEPTACULITES, *De France.*

RECEPTACULITES SUBTURBINATUS, *Hall.*

Plate 2, *Fig.* 1-3.

Receptaculites subturbinatus, HALL. Transactions of the Albany Institute, vol. iv, p. 224. Abstract, p. 30; May, 1863.

Receptaculites subturbinatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Museum edition, p. 103, pl. 3, figs. 1-3, 1879.

Body small, or sometimes approaching the medium size of species of this genus; subhemispheric or depressed subturbinate; base of attachment broad; upper side flat or slightly depressed in the middle for a space of about half of the diameter, thence curving outwards and downwards to the periphery; cell-appertures on the sides and exterior portions of the upper surface distinctly rhomboidal, the width from the lateral angles being greater than the height; cell-margins very prominent; the cells in the central portion obscure.

This small species, in the specimen originally described, has a diameter of nearly twenty-five millimeters; with a height about half as great. It approaches in character to the *R. hemisphericus* of the Niagara formation of Wisconsin.

RECEPTACULITES SACCULUS, *Hall.*

Plate 1, *Fig.* 5.

Receptaculites sacculus, HALL. Trans. Alb. Inst., Vol. X. Abstract, p. 1, 1879.

Body longitudinally subcylindrical, hollow, open at one end (the base?), length less than twice the diameter. Cells irregular in size and arrangement, somewhat smaller near the base, expanding at the aperture to twice the diameter below. Distance between the cell-apertures equal to the diameter of the apertures. Length of cylinder, eighty millimeters; diameter at the base, 55 mm.; diameter at the summit, about 45 mm.; length of cell tubes in the thickest portion of the cylinder, 10 mm.

This species is described from a portion of an individual broken longitudinally through the middle. The fragment is covered with bryozoans rendering some of the characters obscure. It is readily distinguished by its sac-like form, from all other species known in this horizon.

ASTYLOSPONGIA, *Roemer.*

ASTYLOSPONGIA PRÆMORSA, *Goldf.*

Plate 2, *Figs.* 4-11 *and* 14.

Siphonia præmorsa, GOLDF. Petref. Germ., i, 17, t. 6, f. 9. 1826.

Siphonia excavata, GOLDF. Petref. Germ., i, 17, t. 6, f. 8. 1826.

Siphonia præmorsa, HISINGER. Leth. Suec., 94, t. 26, f. 7. 1837.

Siphonia præmorsa, EICHWALD. Silur. Schichtensystems in Esthland, 209.

Siphonia præmorsa, MAXIMILIAN, Herzog von Leuchtenberg. Beschreibung einiger neuen Thierreste der Urwelt aus den Silurischen Kalkschichten von Zarskojeselo. St. Petersburg, 1843, 24.

Siphonia præmorsa, FERD. ROEMER. i. Leonh. u. Bronn's Jahrb., 1848, 684.

Siphonia præmorsa, FERD. ROEMER. i. Lethæa geognost. ed. 3, Th. ii, 154, t. 27, f. 21. 1852–1854.

Siphonia excavata, BRONN. i, Leth. geogn. ed., 3 Th. v. 75. 1851–1852.

Siphonia stipitata, HISINGER. Leth. Suec. 94, xxvi, f. 8.

Jerea excavata, D'ORBIGNY. Prodr. de Pal. strat. ii, 286 1850.

Astylospongia præmorsa, ROEMER. Die Silurische Fauna des Westlichen Tennessee, p. 8, pl. 1, figs. 1, 1a–1c. 1860.

Astylospongia præmorsa, (GOLDF.) HALL. Trans. Alb. Inst., vol. iv, p. 228. Abstract, p. 34; May, 1863.

Astylospongia præmorsa, (GOLDF.) HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Museum edition, p. 103, pl. 3, figs. 4, 11 and 14. 1879.

This widely distributed species which has been illustrated by Goldfuss, Hisinger, Bronn, Roemer and other authors, is a common form at Waldron, but it rarely or never attains the dimensions which it has in the same horizon in Tennessee, where it is even more common than in Indiana.

The usual dimensions of the Waldron specimens vary from ten to twenty millimetres in lateral diameter, with a vertical diameter of about one-sixth less than the lateral. There is much variation in the strength and number of the furrows and prominence in the lobes, and also in the depth and diameter of the depression at the center of the summit.

The interior structure is represented in figs. 9, 10, 11, as it appears under an ordinary lens. In all the specimens which have been cut, there is evidence of an original central cavity, filled with mineral matter which does not preserve structure.

ASTYLOSPONGIA PRÆMORSA, var. NUXMOSCHATA, *Hall.*

Plate 2, *Figs.* 12, 13.

Astylospongia præmorsa, var. nuxmoschata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; mus. ed., p. 104, pl. 3, figs. 12, 13, 1879.

Form, an oblate spheroid with the entire surface traversed by numerous interrupted and unequal grooves or subconfluent pits giving a rugose aspect; the sides marked by a few narrow scarcely defined sulci, which do not reach the summit; summit elevated and without the central depression possessed by typical forms of the species. Entire surface covered by minute pustulose elevations, which, under an ordinary lens do not show structure. The minute interior structure has not been determined.

This form was included under *A. præmorsa* in the Documentary edition of the 28th Rept. N. Y. St. Mus. N. H., but was separated as a variety in the museum edition. It occurs in association with the other forms of Pretrospongia at the Waldron locality.

Astylospongia imbricato-articulata, *F. Roem.*

Siphonia imbricato-articulata, Ferd. Roemer. In Leonh. u. Bronn's Jahrb., 1848, 685, ix, fig. 3.

Astylospongia imbricato-articulata, F. Roem. Die Sil. Fauna des Westl. Tennessee, p. 12, pl. 1, figs. 5, 5a. 1860.

Astylospongia imbricato-articulata, (F. Roem.) Hall. 28th Rep. N. Y. St. Mus. Nat. Hist.; mus. ed., p. 104. 1879.

A single specimen of this species or a closely allied form, has been observed among some recent collections from Waldron.

Astylospongia (Palæomanon) bursa, *Hall.*

Plate 1, *Fig.* 4; *Plate* 2, *Figs.* 15, 16.

Astylospongia? (*Palæomanon*) *bursa*, Hall. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 3, figs. 15, 16. 1876.

Astylospongia (*Palæomanon*) *bursa*, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist.; mus. ed., p. 105, pl. 3, figs. 15, 16. 1879.

Compare *Palæomanon cratera*, Roemer. Die Silur. Fauna des Westl. Tenn., p. 13, pl. 1, f. 4, 4a. 1860. Also, *Aulacopina Granti*, Billings. Canadian Naturalist and Geologist. 1875.

Body calyciform, elongate semi-elliptical in outline, regularly rounded below and curving upwards, the sides above the middle of the height nearly straight.

Surface finely punctate and marked by elongate subconfluent pits.

The specimen figured has been laterally compressed, so that the true form would be narrower than represented in figure 15. Some specimens of recent collections with shorter and comparatively broader cups, have essentially the same general aspect of surface as this; but the large pits upon the surface are less confluent, and it is possible that these forms may be allied to *Palæomanon cratera* of Roemer, but their condition of preservation does not admit of satisfactory reference.

A single specimen (pl. 1, fig. 4) with a proportionally narrower form than shown in fig. 15, presents, on a part of its surface, numerous and closely arranged stelliform spiculæ which appear to be superficial, while the surface beneath is finely punctate.

The imperfect preservation of all the larger forms of sponges in the Waldron collections is such as to render difficult and unsatisfactory any specific determinations from external form and character alone.

HYDROZOA.

DENDROGRAPTUS, *Hall.*

DENDROGRAPTUS (s. g. CHAUNOGRAPTUS) NOVELLUS, *Hall.*

Plate 1, *Figs.* 1, 2.

Dendograptus (*s. g. Chaunograptus*) *novellus*, HALL. Trans. Alb. Inst., Vol. X. Abstract, p. 2, 1879.

Fossil occurring free in the shales, or upon other fossil bodies, in slender branching fronds. Branches diverging, lax and slender, with numerous branchlets, both marked by numerous cellules which are usually indicated by the appearance of abrupt expansion and contraction of the branches.

The angular projection of the cell-aperture can be observed in many parts of the fossil.

This species is more lax and diffuse than any form of DENDROGRAPTUS known, and therefore has been separated from the typical forms of the genus. It occurs free among other fossils, or attached to some fragmentary portions of other bodies. In its habit of growth it is quite distinct from any of the forms heretofore illustrated, and it is probable it belongs to a division of the Hydrozoa which has not been recognized in the palæozoic formations.

INOCAULIS, *Hall.*

INOCAULIS DIVARICATA, *Hall.*

Plate 1, *Fig.* 3.

Inocaulus divaricata, HALL. Trans. Alb. Inst., Vol. X. Abstract, p. 2, 1879.

Frond ramose, regularly branching at intervals about ten millimeters by dichotomous division. Branches straight, diameter 2 mm., diverging at an angle of nearly 85°, giving the frond a somewhat rigid appearance. Exterior structure composed of numerous irregular, longitudinally striated, branching filaments, connected by slender dissepiments, forming rows of small, irregular, sub-angular cell-apertures.

This species is distinguished from *I. plumulosa*, HALL (*Pal. N. Y.*, vol. ii, p. 176), by its rigid, slender, diverging branches, and by the absence of the projecting, imbricating scales forming the cell-margins.

The specimen here described furnishes some additional evidence regarding the intimate structure and nature of INOCAULIS.

CORALS AND BRYOZOA.

STREPTELASMA, *Hall.*

STREPTELASMA RADICANS, *Hall.*

Plate 4, *Figs.* 1-4.

Streptelasma (*Aulacophyllum?*) *radicans*, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 5, figs. 1-4. 1876.

Streptelasma radicans, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Ed., p 106, pl. 5, figs. 1-4. 1879.

Corallum simple turbinate, usually irregular in its growth below, or truncate, from attachment to other bodies; sometimes with radiciform extensions, often curved near the base; calyx circular, deep; dissepiments strong, a section showing twenty to twenty-two extending half-way to the center, with an equal number of short intermediate ones. A single specimen cut longitudinally shows no horizontal diaphragms, and the inner margin of the rays are crenulate.

Exterior strongly marked by the radiating ridges of the dissepiments, and usually pretty regulary enlarging from the base, though sometimes showing irregularities due to contraction and expansion of growth. Height of specimens from 25 to 40 millimeters.

This species is of common occurrence in the Waldron locality.

STREPTELASMA (DUNCANELLA) BOREALIS, *Nicholson.*

Plate 1, *Figs.* 7-10; *Plate* 4, *Figs.* 7, 8.

Duncanella borealis, NICHOLSON. Ann. and Mag. Nat. Hist., 4th series, vol. xiii. 1874.

Streptelasma minima, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 5. 1876.

Streptelasma (*Duncanella*) *borealis*, NICHOLSON. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Ed., p. 106, pl. 5, figs. 7 and 8. 1879.

Corallum simple elongate-obconical: calyx deep, circular, scarcely expanding at the margins beyond the general enlargement of growth; rays, coarse and strong; epitheca strongly marked by vertical striæ indicating the rays, and usually by distinct striæ of growth which sometimes obscure the rays; epitheca rarely covering the base, leaving the rays exsert; these, to the number of nine or ten, and sometimes twelve, coalesce in the center, gradually increasing in number with the growth of the coral till there are from seventeen to nineteen at the margin of the calyx. Length, twenty millimeters.

With the exception of the exsert septa at the base, this coral has all the characteristics of STREPTELASMA in the arrangement of the radiating septa which coalesce near the base and for some distance upwards, above which the lamellæ approach the center, leaving a cylindrical cavity which gradually expands above.

ZAPHRENTIS, *Rafinesque.*

ZAPHRENTIS CELATOR, *Hall.*

Plate 4, *Figs.* 5, 6.

Zaphrentis? celator, HALL. Doc. Ed. 28th Rep. N. Y. St. Mus. Nat. Hist. Explanation of pl. 5, figs. 5, 6. 1876.

Zaphrentis celator, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Ed., p. 107, pl. 5, figs. 5, 6. 1879.

Corallum turbinate, rapidly expanding from below, with irregularities of growth, producing expansion and contraction of the cup. Calyx deep and broadly expanded, the width of the specimen figured being nearly as great as the height. Dissepiments, sixty or more.

This species is of rare occurrence in the collections from the Waldron locality.

AULOPORA, *Goldfuss.*

AULOPORA PRECIUS, *Hall.*

Plate 8, *Figs.* 5, 6.

Aulopora precius, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 9, figs. 5, 6. 1876.

Aulopora precius, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Ed., p. 107, pl. 9, figs. 5, 6. 1879.

Corallum parasitic, consisting of elongate, tubular cells which in their progress of growth usually conform to the surface on which they grow, somewhat gradually enlarging to the aperture. Calyces budding laterally in a direct line, or sometimes geminating, and diverging at an angle of from 45 to 80 degrees. After budding, the parent cup turns upwards and ceases to grow in that direction. The corallum sometimes spreads over a considerable extent of surface, and in other examples the calyces are crowded and grow nearly directly upwards, attaining an elevation above the attached base of three to five millimeters. In the procumbent forms the distance between the budding is about 4 to 5 mm., the diameter of the tube at its origin is less than 1 mm., the aperture including the exterior walls being about 2 mms.

This species bears some resemblance, in its mode of growth, to the *Aulopora Schohariæ*, but is a stouter species, except in rare examples where the tubes are more slender than in the prevailing forms.

FAVOSITES, *Lamarck.*

FAVOSITES SPINIGERUS, *Hall.*

Plate 3, *Figs.* 1–5; *Plate* 8, *Figs.* 1, 2.

Favosites Niagarensis, var. *spinigera*, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 4, figs. 1–5. 1876.

Favosites excretus, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 9, figs. 1 and 2. 1876.

Favosites spongilla, ROMINGER. Fossil Corals, page 24; reference under the head of *Favosites pyriformis*, 1876.

Favosites spinigerus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Ed., p. 108, pl. 4, figs. 1–5. 1879.

Form hemispheric or pyriform, often spreading and becoming lobed above. Tubes small, ranging from one to one and a half millimeters, the lateral walls with radiating spinulæ; diaphragms essentially flat, mural pores not determined, cell-apertures irregularly margined by spiniform processes.

This small species occurs in subhemispheric forms of from 10 to 25 mm. in diameter and of somewhat less elevation; it also assumes pyriform shapes of similar dimensions, often becoming expanded and variously lobed above. The apertures of the cells, as usually presented, are extremely variable in size, and there is not unfrequently a group of smaller cells arranged around a larger one, and in the irregular mode of growth the margins become free and more or less curved. In rare examples the apertures are free, rounded, and a little dilated, while on the margins of the mass the tubes are subcylindrical with individual epithecæ. In such forms the apertures present an appearance as of one cell budding from the calyx of another, but this aspect is probably due to a thickening of the cell-wall or an abrupt contraction of growth.

In specimens where the aperture is expanded, the diaphragms, visible from above, are convex with a little boss in the center.

This is undoubtedly the species indicated by Dr. Rominger as *F. spongilla*, but at the time of printing the explanations of plates for the Documentary Edition of the 28th Report N. Y. St. Mus., his work had not been published.

FAVOSITES FORBESI, var. OCCIDENTALIS, *Hall.*

Plate 1, *Figs.* 11-14; *Plate* 3, *Figs.* 6-15.

Favosites Forbesi? (EDWARDS & HAIME) HALL. Doc. Edit. Rep. St. Mus. Nat. Hist. Explanation of pl. 4, figs. 6-15. 1876.

Favosites Forbesi var. occidentalis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. Ed., p. 109, pl. 4, figs. 6-15. 1879.

Compare *F. Forbesi*, EDWARDS & HAIME. British Fossil Corals, p. 258, pl. 60.

Corrallum hemispheric, subglobose or pyriform; calyces very unequal in size, the larger ones often subcircular and about three millimeters in diameter, while the smallest cells are often not more than 1 mm. at their apertures. In rare specimens the diameter of the larger calyces does not exceed 2 mm. A vertical section shows the walls to be of medium thickness, while in the calyces they appear strong and are often crenulate from the longitudinal striæ. Mural pores, situated near the angles, in one or two ranges, depending on the size of the cell. Cell-wall granulose, the granulæ arranged in transverse lines.

The form and dimensions of the coral are fairly represented in the figures on plate 3, and few larger specimens have been observed than the one illustrated in figure 10. The species is very abundant, occurring in great numbers in the shaly limestone deposits of Waldron and vicinity. In many of the specimens the epitheca is extended from the bases over the sides of the coral, covering the cell-apertures, and not unfrequently some of the larger cells upon the upper face of the coral are partially closed by an individual epithecal covering, which growing inward from the margins finally closes the aperture, after the manner of an operculum with a central node. In some examples this epithecal growth begins within the calyx walls, presenting a distinct ring with a central circular opening, giving the appearance of budding from the parent cell, but in the progress of growth the space between the cell-walls and the epithecal ring is closed and the central opening becomes in like manner filled.

This species has been identified with *F. Forbesi*, chiefly from its similarity with the young of that species, as represented by Edwards & Haime, *British Fossil Corals*, plate 60, though our specimens very rarely assume the form there illustrated, which is similar to one figured by Dr. F. Roemer, from the Silurian of West Tennessee. We have no specimens presenting the characters of the older individuals represented from the Wenlock limestone, though the few larger specimens which have come under examination do not show the great diversity in the size of the calyces which appears in the smaller corals. The position and character of the mural pores in the European species is not stated in the description. The strongly pustulose character of the cell-walls as represented in the British specimens has not been observed in the American forms.

CLADOPORA, *Hall.*

CLADOPORA SARMENTOSA, *Hall.*

Cladopora sarmentosa, HALL. Trans. Alb. Inst. vol. X, abstract, p. 3. 1879.

Frond ramose, solid, frequently branching, diameter from two to four millimeters; cell-tubes radiating equally on all sides from the axis at an angle of 45°, gradually enlarging toward their apertures, which are about .75 mm. in diameter, and closely arranged in alternating series, the apertures having their lower sides margined by a projecting lip which gradually slopes into the substance of the branch below.

This species bears some resemblance to *C. seriata*, HALL, of the Niagara group of New York, but differs from that species in its stronger and more frequent branches enlarging at their bases; and in the gradual diverging of the cell-tubes from the axis. Specimens of this species are very rare.

CHÆTETES, *Fischer.*

CHÆTETES CONSIMILIS, *Hall.*

Plate 8, *Figs.* 7-14.

Compare *Trematopora solida*, HALL. Pal. N. Y., vol ii, p. 153, pl. 40 A, figs. 6 *a*, 6 *b*, 6 *c*. 1852.

Chætetes? consimilis, HALL. Doc. Edit. 28th Rap. St. Mus. Nat. Hist. Explanation of pl. 9, figs. 7-14. 1876.
Chætetes consimilis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed., p. 110, pl. 9, figs. 7-14. 1879.

Frond solid, ramose, frequently branching, branches in the larger specimens having a diameter of six millimeters. Cell-tubes polygonal rising from the center of the branches and gradually diverging to the surface. Cell-walls thin, strongly corrugated, transverse diaphragms extremely rare or entirely wanting. Apertures .35 mm. in diameter.

In well-preserved specimens the cell-walls at the apertures are granulose and have minute spines at the angles of the cells.

This species occurs in such forms as are figured on plate 8, presenting in the different conditions of weathering, the phases represented in the enlarged figures 8, 10, 12 and 14.

TREMATOPORA, *Hall.*

TREMATOPORA OSCULUM, *Hall.*

Plate 9, *Figs.* 5-8, 11-14.

Trematopora osculum, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 10, figs. 3-12 (3 and 4 in error). 1876.
Trematopora osculum, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed., p. 110, pl. 10, figs. 5-8, 11-14. 1879.
Comp. *T. ostiolata*, HALL. Pal. N. Y., vol. ii, p. 152, pl. 40A, figs. 5*a*-5*n*. 1852.

Frond ramose, hollow, with an interior epitheca, branching infrequently; diameter of branches from one and a half to two millimeters; thickness of the substance of the bryozoum, .35 mm. Cell-tubes oval; apertures .3 mm. in length, closely arranged in quincunx order, forming oblique rows, opening upward and outward; usually the lower side of the aperture is margined by a projecting semi-circular lip, which partially covers the opening; rarely the upper margin of the aperture is also elevated.

This is the most common form of the genus in the Waldron locality, and is very abundant.

TREMATOPORA INFREQUENS, *Hall.*

Plate 9, *Fig.* 3 *in part, and Fig.* 4.

Trematopora infrequens, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 10, figs. 13, 14 (in error for 3 and 4). 1876.

Trematopora infrequens, HALL, 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed. p. 111, pl. 10, fig. 3 in part, and fig. 4. 1879.

Frond ramose, hollow, the inner surface marked by a wrinkled epitheca; branches from one and a half to two millimeters in diameter; bryozoum about .35 mm. in thickness. Cell-tubes oval, rising obliquely from the epitheca to the exterior surface. Length of aperture about .3 mm., with the margin distinctly and equally elevated, occasionally presenting a serrated appearance; apertures separated by distances equal to their diameters, arranged in quincunx order, presenting a spiral arrangement around the branches.

This species may be distinguished from *T. osculum* by its larger cells, and by the cell-margins being strongly and equally elevated in every portion, while in that species the lower margin of the aperture is almost always more strongly elevated than the upper portion.

TREMATOPORA VARIA, *Hall.*

Plate 9; *Figs.* 15-23.

Trematopora varia, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 10, figs. 15-23. 1876. Mus. Ed., p. 111. 1879.

Frond ramose, hollow, inner surface transversely wrinkled; branches frequent, from two to seven millimeters in diameter. Bryozoum about 1 mm. in thickness. Cells tubular, oval or circular, from 1 to 1.5 mm. in length; for the first half of their extent growing nearly parallel with the inner surface, and then turning abruptly outward; diameter at the aperture .25 mm., varying from circular to elongate-oval, arranged irregularly from contiguity to a distance equal to the diameter, with frequent maculæ which are destitute of cells. Cell-margins in well-preserved specimens distinctly elevated, and frequently finely serrated.

In specimens where the maculate surface is well-preserved, the adjacent cell-apertures often have their longest diameter in a radiating direction from the center of the maculæ. The cell-apertures in this species vary from circular to elongate-oval or ovate, both forms sometimes occurring on the same specimen, while in worn specimens the apertures appear to be polygonal.

TERMATOPORA ECHINATA, *Hall.*

Plate 10; *Figs.* 1–5.

Trematopora echinata, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 1–5. 1876. Mus. Ed. p. 112. 1879.

Bryozoum solid, ramose; branches from .75 to 1.5 mm. in diameter, frequently widely diverging, sometimes at an angle of 80° or 90°. Cell-tubes polygonal, generally hexagonal, commencing at the center of the branch and gradually diverging to near the surface, where they turn abruptly outward. Cell-apertures longer than wide, length from about .3 mm. to .55 mm., the width being from one-half to two-thirds their length, having at the angles of the margins slender, sharp spines.

This species is very abundant, often nearly covering the surfaces of the calcareous slabs, and imbedded in the softer shales. It presents much variation in the size of the cell-apertures, and their distribution on the surface is sometimes interrupted and irregular. The prevailing form is represented in fig. 4, plate 10. In many examples the smaller stipes and branches are marked by the larger cell-apertures.

TREMATOPORA GRANULIFERA, *Hall.*

Plate 10, *Figs.* 6, 7.

Trematopora granulifera, HALL. Pal. N. Y. vol. ii, p. 154, pl. 40 A. figs. 9a, 9c. 1852.
Trematopora granulifera (n. sp. in error.), HALL. Doc. Ed., 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 6, 7. 1876.
Trematopora granulifera, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed. p, 112, pl. 11, figs. 6, 7. 1879.
Compare *T. regularis,* HALL. 26th Rep. N. Y. St. Mus. Nat. Hist., p. 106. 1873.

Bryozoum ramose, solid; branches one millimeter or less in diameter. Cells tubular oval, rising from the center of the branch and increasing by interstitial additions. Length of apertures .3 mm., with a width of .15 mm., arranged upon the surface in a somewhat quincunx order, being in right lines longitudinally, and in a spiral order around the stipe. Margins of apertures elevated and strongly granulose; the spaces between being flat or channeled. The borders of the apertures are sometimes coalescent, and present no intermediate groove.

TREMATOPORA MINUTA, *Hall.*

Plate 10, *Fig.* 8.

Trematopora? (Trachypora?) minuta, HALL. Doc. Edit. of 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, fig. 8. 1876.
Trematopora minuta, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed. p. 113. pl. 11, fig. 8. 1879.

Bryozoum ramose, very slender: branches frequent, widely diverging; diameter, .5 millimeters. Cell-apertures elongate-oval, length about .4 mm., and width .2 mm.; distance from each other longitudinally about equal to the length of an aperture, arranged in spiral rows along the branch. Margins distinctly elevated and granulose, and separated from each other by tortuous lines of nodes.

This species differs from *T. macropora* by its more elongate cell-apertures and the more prominent granulose ridges.

TREMATOPORA VARIOLATA, *Hall.*

Plate 10, *Figs.* 9, 10.

Termatopora variolata, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, fig. 9, 10. 1876. Mus. ed., p. 113 1879.

Bryozoum ramose, hollow, diameter of the branches from 1 to 1.5 millimeters. Cell-apertures oval, margins distinctly elevated, length .3 mm., width .2 mm., sometimes closely arranged, and in other cases irregularly scattered; surface with numerous maculæ which are quite destitute of cells.

This species can readily be distinguished from any other form in this association by the scattered and irregular distribution of the cell-apertures and the numerous maculæ without cells.

TREMATOPORA SUBIMBRICATA, *Hall.*

Plate 9, *Figs.* 9, 10.

Termatopora subimbricata, HALL. Trans. Alb. Inst. vol. X, abstract, p. 4. 1879.

Bryozoum ramose; branches straight, hollow; inner surface transversely wrinkled; cellules rising from the epitheca and continuing with slight obliquity to near the surface, where they curve outward almost rectangularly to the axis. Cell-apertures oval, about two-thirds as wide as long, often closely arranged or crowded, upper side without elevated margin, lower side with a projecting lip. In some parts of the surface there are maculæ of larger and more irregularly disposed cells.

This species resembles *T. osculum* in its general aspect; but the branches are stronger, and the cell-apertures irregularly disposed. In that species the smaller and more regularly arranged cells are marked by a projecting border on the upper margin.

TREMATOPORA SPICULATA, *Hall.*

Plate 10, *Figs.* 11, 12.

Trematopora spinulosa, HALL. Doc. Edit. Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 11, 12. 1876.
Trematopora spiculata, HALL. Miller's Cat. Pal. Foss., p. 245. 1877.
Trematopora spiculata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. Ed. p. 114, pl. 11, figs. 11, 12. 1879.
Not *Trematopora spinulosa*, HALL. Pal. N. Y. vol. ii. p. 155, pl. 40 A, figs. 11a, 11b. 1852.

Bryozoum solid, ramose; branches frequent and not widely diverging; diameter from 1.5 to 2 millimeters. Cell-tubes polygonal, arising from the center of the branch and gradually diverging till within half a millimeter of the surface when they turn abruptly outward; at the point of turning, the cell-walls, previously thin, become thickened. No transverse septa are visible till near the surface, where they are numerous and distant from each other about the width of the cell-tubes. Cell-apertures variable in size, the larger ones being about .16 mm. in diameter, irregularly arranged and having short, stout spinules at the angles.

This species is readily distinguished by its solid aspect, minute cells which are variable in size, and the comparatively strong spinules which disguise the cell-apertures and give a uniform asperate aspect to the surface. Sometimes the cell-margins are worn flat and the cells appear oval. It differs from *T. echinata* in its more robust aspect, and the smaller and less elongate cells.

TREMATOPORA (CHÆTETES) CREBRIPORA, *Hall.*

Trematopora (*Chætetes*) *crebripora*, HALL. Trans. Alb. Inst. vol. X. Abstract p. 3. 1879.

Frond ramose, branches infrequent, moderately diverging; substance solid from the filling of numerous small subcylindrical cells, which, originating at or near the center, gradually diverge to near the surface, where they turn directly outward. Cell-apertures oval, from one and a half to two millimeters in length and about two-thirds as wide as long; irregularly arranged, often contiguous, but preserving the oval form. Septa few or none.

It differs from *T. varia* in its larger and distinctly oval cell-apertures, and its solid branches.

TREMATOPORA? (TRACHYPORA?) MACROPORA, *Hall.*

Trematopora ? (*Trachypora ?*) *macropora*, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 4. 1879.

Bryozoum branching; branches slender, solid, infrequent, diameter .5 millimeter. Cell-apertures oval, very large in comparison with the branches, about .3 mm. in length and .2 mm. in width, with elevated and granulose margins; the apertures arranged in spiral rows, the distance between them a little more than their length. Interspaces covered with fine granules.

This species is distinguished from *T. minuta* by the absence of the strong longitudinal rows of nodes, which in that species are more elevated than the cell-margins, while in this one that character is reversed. The minute granulæ upon the surface show that the differences observed are not due to weathering or maceration.

CALLOPORA, *Hall.*

The name CALLOPORA, which is claimed by some authors to be identical with FISTULIPORA of McCoy, is continued for the reason that the author of the latter genus (*British Palæozoic Fossils*, p. 11) says that "this genus was proposed to include the *Manon cribrosum* (Gold.) of the Eifel, etc., and some new species." The *Manon cribrosum* of Goldfuss is recognized by European palæontologists as a specimen of *Heliolites interstincta.* Again, in describing *F. decipiens*, the author says: "So exactly does this resemble the *Palæopora interstincta*," etc. The figures of *F. decipiens* scarcely resemble CALLOPORA in its ordinary forms. See *Descriptions of Lower Helderberg Corals and Bryozoa* for further observations on these genera.

CALLOPORA SINGULARIS, *Hall.*

Plate 9, *Figs.* 1, 2.

Callopora singularis, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 10, figs. 1, 2. 1876. Mus. Ed., p. 115. 1879.

Frond ramose, solid, diameter of branches two millimeters. Cells tubular, oval, or polygonal, arising from the center of the branch and gradually diverging till near the surface when they turn and open nearly directly outward. Cell-apertures .3 mm. in length, with a width of .2 mm., irregularly arranged, varying in distance from contiguity to a space equal to the length of the aperature; margins distinctly elevated, frequently crenulated by minute spinules. Intercellular spaces on the surface occupied by minute pits, which are observable only on well-preserved specimens.

Translucent sections of the stipes or branches present no evidence of intercellular vesiculose structure, and have all the aspect of a TREMATOPORA. This condition may come from a solidifying of the intercellular substance during the process of petrifaction, leaving only the intercellular pits upon the surface.

CALLOPORA ELEGANTULA, *Hall.*

Callopora elegantula, HALL. Pal. N. Y., vol. ii, p. 144, pl. 40, figs. 1, 2. 1852.

Bryozoum consisting of cespitose or fruticose groups, frequently branching; branches bifurcating or variously diverging from the stems, solid, extremities often hollow, or having a cup-like termination; apertures of cells circular, with intermediate angular cellular spaces; the circular apertures often having a smaller central point, or circle with rays extending to the outer walls. Intercellular spaces variable in extent, often irregular; circular openings of cells usually destitute of rays; cells tubular, extending to the axis in solid specimens, often filled and separating in prismatic structure.

This species as recognized among the collections from Waldron, possesses all the essential characters of the specimens from the Niagara groups of New York. It may be readily determined from other associated forms of this genus by the large circular, distant, and somewhat irregular cell-pores.

CALLOPORA CERVICORNIS, *Hall.*

Callopora cervicornis, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 3. 1879.

Frond ramose, branches round or flattened, solid, irregular in their mode of growth, diverging at an angle of 90°, diameter of branches reaching eight millimeters Cellules rising from the center and gradually ascending to near the surface, where they turn abruptly outward; cell-walls very thin; septa very infrequent; cell apertures oval, .3 mm. long, .2 mm. wide, closely arranged, with elevated margins which are often granulose. Intercellular spaces very narrow or sometimes wanting, leaving the cell-margins in contact.

CALLOPORA EXSUL, *Hall.*

Plate 8, *Figs.* 3, 4.

Alveolites exsul, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 9, figs. 3, 4. 1876.

Callopora exsul, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed., p. 115, pl. 9, figs. 3, 4. 1879.

Bryozoum consisting of lamellose expansions, free or incrusting other organic bodies, celluliferous on one side; lower surface formed of a wrinkled epitheca; substance of frond sometimes very thin, and often thickened by successive accretions of growth. Cell-apertures oval, from .3 to .5 millimeter in length, and usually about two-thirds as wide as long, sometimes nearly circular, closely and irregularly arranged. Intercellular space usually occupied by a single series of angular pits. Margins of cell-apertures elevated, and ornamented by from two to five short spinules. A transparent section shows an intercellular vesiculose structure, with transverse septa in the cell-tubes.

The more recent collections from Waldron contain a considerable number of specimens of this species in various conditions of preservation. The better specimens preserve the short spinules surrounding the cell-apertures, with a distinct row of pits marking the intercellular space. In some of the specimens the spinulæ are more or less worn away or irregularly preserved, and in further wearing, the intercellular spaces appear as thick, solid walls separating the cell-apertures. The specimen originally figured as *Alveolites exsul* is evidently a CALLOPORA encrusting and only partially covering the surface of *Ceramopora confluens*. The illustration in figure 4 of plate 8, is incorrect in representing the cell-apertures as angular and oblique, while the cells open directly upwards; the intercellular spaces are thicker and covered with granulæ, and are formed by numerous very small angular pits or pores.

It is distinguished from a condition of *Ceramopora confluens* by the intercellular granulæ and pits.

CALLOPORA? DIVERSA, *Hall.*

Callopora? diversa, HALL. Trans. Alb. Inst. Vol. X. Abstract, p. 4, 1879.

Frond ramose, solid; branches infrequent, strong and usually somewhat compressed, often much thickened below the bifurcations, and presenting a clavate form. A longitudinal section shows the cells gradually divergent from the centre and turning abruptly outward near the surface; cell-walls with strong and regular corrugations, about four in the space of one millemeter; septa wanting or very infrequent; cell-apertures usually subcircular, sometimes distinctly oval and often subangular from close proximity, with distinct spines at the angles, and sometimes with margins entirely granulose. Intercellular spaces sometimes marked by a single series of pits upon the surface, but usually this feature is absent or obsolete; a section of a branch shows the septate intercellular spaces extending a short distance below the surface.

This species, in its solid structure, and its intercellular spaces, seen only near the surface, so closely resembles CHÆTETES that there is little reason for separating it from that genus. It can be distinguished from *Callopora cervicornis* by its stronger habit, more circular cell-apertures, and conspicuous maculæ with larger cells.

LICHENALIA, *Hall.*

LICHENALIA CONCENTRICA, *Hall.*

Plate 4, *Figs.* 9-16; *Plate* 5, *Figs.* 1, 2, 4, 7-10, *and Plate* 6, *Figs.* 3-11.

Lichenalia concentrica, HALL. Pal. N. Y., vol. ii, p. 171, pl. 40E, figs. 5a-5g. 1852.
Lichenalia concentrica, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. ed., p. 116, pl. 5, figs. 9-16; pl. 6, figs. 1, 2, 4, 7, 10, pl. 7, figs. 3, 11. 1879.

The name LICHENALIA* was originally applied to circular or flabelliform epitheeal expansions, one side of which is concentrically wrinkled, and when in perfect condition is usually marked by fine radiating and concentric striæ, which vary in character and degree in different species. The opposite side is celluliferous. The celluliferous face is usually adherent to the stone, and the exposed surface presents the ordinary characters of the epitheeal covering of a coral or bryozoum. In well-preserved examples the fine concentric and radiating striæ are apparently characteristic of the genus, and in some specimens the cell-bases are visible from the non-celluliferous face. When the exterior surface is worn, it presents a grooved and striate appearance, indicating the mode of growth in the cells and cell-walls, which are usually procumbent at the commencement of their growth, and then turn upward. The celluliferous face presents numerous cell openings which may be closely or more distantly arranged, and which vary from circular to oval, and even subquadrangular in form, depending upon their mode of growth and in part upon the condition of preservation. These bodies do not always preserve the expanded form indicated, but the margins become contracted and infolded, so that the non-celluliferous faces come into near contact, and assume an apparently solid form, with cell-apertures covering the entire surface. In their young state they are frequently found attached to other fossils, and this is probably the condition of all in their earlier stages of growth; the mode of growth and ultimate form being greatly dependent upon the nature of the body to which the germ has originally been affixed. In the expanded forms the cell-tubes are short, and the increase is by lateral formation of new cells, until the fronds sometimes reach a diameter of thirty centimeters. When the frond becomes corrugated or infolded in its young state, and assumes a compact form, the cell-tubes become elongated as shown in fig. 11 of plate 4, but we are unable to find that any of them assume characters incompatible with the genus in its typical forms. After examining a large number of specimens, it is impossible to distinguish any characters marking a specific difference between the expanded forms, like figs. 4, 9, 10, of plate 5, and those which assume an irregular and more solid aspect, as in figs. 9, 11 and 12, of plate 4.

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* Paleontology of New York, vol. ii, p. 171.

LICHENALIA CONCENTRICA, var. PARVULA, *Hall.*

Lichenalia concentrica, var. *parvula*, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 7, figs. 1, 2. 1876. Museum Edition, p. 117, 1879.

This form, indicated as a variety of *L. concentrica*, is distinguished by its smaller cell-apertures, as shown in fig. 2, which is enlarged to the same degree as fig. 7. In its mode of growth and other characters it does not differ from the ordinary forms of LICHENALIA.

LICHENALIA CONCENTRICA, var. MACULATA, *Hall.*

Plate 5, *Figs.* 3, 5, 6.

Lichenalia concentrica, var. *maculata*, HALL. 28th Rept. N. Y. St. Mus. Nat. Hist.; Mus. Ed., p. 117, pl. 6. figs. 3, 5, 6. 1879.

Celluliferous face, flat, concave or convex; cell-apertures round, or broadly oval, and when entire, preserving a projecting lip on one side; variable in their distance from each other, and sometimes quite closely arranged. Surface marked by elevated maculæ, upon which there are a few larger cell-apertures irregularly disposed, the center of the tubercle being sometimes quite free from cells.

The specimen figured has a convex exterior surface, owing to the contraction of the epitheca, and on some weathered portions, where the cell-apertures are distant, the interspaces are apparently cellulose. This feature, however, is not a prevailing one, nor has it any specific signification. In a specimen where the celluliferous face is concave, the exterior or epitheeal side presents the same aspect as that of ordinary forms, and is undistinguishable from them. The maculate form of surface, or its incipient condition, is very common upon all forms of the celluliferous face of this fossil.

This variety is separated from the forms figured as *L. concentrica* in the Documentary Edition of the 28th Report N. Y. St. Mus. Nat. Hist.

SAGENELLA, *Hall.*

SAGENELLA ELEGANS, *Hall.*

Plate 6, *Figs.* 12, 13.

Sagenella elegans, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 7, figs. 12, 13. 1876. Museum Edition, p. 118. 1879.

Compare *S. membranacea*, HALL. Pal. N. Y., vol. ii, p. 172, pl. 40E, figs. 6 *a*, 6 *b*.

Bryozoum a thin membraniform expansion growing upon the surface of other organic bodies. Cells subcylindrical, flattened for the greater portion of their length and continuing nearly parallel with the plane of the epitheca; arranged in a more or less diverging or radiating order, with intercalated ranges, presenting a subimbricated aspect, turning abruptly and opening upward. Cell-apertures circular, about two millimeters in diameter.

The arrangement of cells and form of cell-apertures differ from CERAMOPORA in the rounded form and more directly upward opening. The genus differs from LICHENALIA in the more extended procumbent portion of the cell-tube, in the form of the cell-aperture, and in the much thinner and persistently adhering epitheca.

CERAMOPORA, *Hall.*

CERAMOPORA LABECULA, *Hall.*

Plate 7, *Figs.* 1-3.

Ceramopora ? (*Berenicia ?*) *labecula* HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 1-3. 1876; Mus. ed., p. 119. 1879.

Compare *Ceramopora imbricata*, HALL. Pal. N. Y., vol. ii, p. 169, pl. 40E. figs. 1*a*, 1*i*. 1852.

Bryozoum growing in circular or subcircular discoid forms upon other organic bodies; greatest diameter observed about seven millimeters. Cell-tubes short, cylindrical, radiating from the center and increasing by lateral additions, those in the central portion being nearly vertical, and becoming more and more oblique as they recede from this point, until the marginal ones are nearly parallel with the epitheca; arranged in alternating and imbricating series. Apertures arched or somewhat triangular, .25 mm., or less, in diameter.

This species is found attached to the bases of crinoids, to gasteropods, and other fossils.

CERAMOPORA CONFLUENS, *Hall.*

Plate 7, *Figs.* 4, 5.

Ceramopora confluens, HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 4, 5. 1876. Museum Edition, p. 119. 1879.

Bryozoum, consisting of lamellose expansions growing upon the surface of other organic bodies, and attaining a thickness of from .25 to 1 millimeter. Cell-tubes short cylindrical, closely arranged in alternating and imbricating order. Surface often elevated in nodose prominences which are sometimes destitute of cells. Cell-apertures arching or triangular, about four in the space of 1 mm.

This species occurs in large expansions growing upon shells and upon the calyces of crinoids. The surface of the expansion rises into low rounded nodes and irregular undulating ridges, the summits of which are sometimes free from cellules, while in many examples there a few larger cellules marking the sides of the elevation. The cell-apertures are usually closely arranged, sometimes more distant, and when entire, have the typical arching form, but where the surface is worn, they are round or broadly oval.

This species differs from *C. agellus* in not showing lines of cellules radiating from the maculæ or nodes, and in the less distinct elevation of the cell-tubes upon the surface.

CERAMOPORA AGELLUS, *Hall.*

Plate 7, *Fig.* 6.

Ceramopora agellus HALL. Doc. Edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, fig 6. 1876. Museum Edition, p. 120. 1879.

Bryozoum consisting of a thin expansion covering the surface of other organic bodies; cells subcylindrical, short, very oblique, rapidly expanding toward the apertures. Cell-apertures, when entire, arching and angular, and when worn, broadly elliptical; about four in the space of a millimeter on the greater part of the surface, and upon the maculæ, two or three in the same space.

The surface of the frond is marked by numerous maculæ which do not rise into nodes, but are covered by cells of from once and a half to twice the diameter of the ordinary cells. The cellules of the entire frond appear to radiate from a single point, which is not the centre, and again from each of the maculæ are distinct radiating lines of cellules in the direction of the growth. In these characters the species differs from *C. confluens*. This species occurs upon the surface of Gasteropoda and Brachiopoda, but has rarely been seen upon the calyces of crinoids.

CERAMOPORA RARIPORA, *Hall.*

Ceramopora raripora, HALL. Trans. Alb. Inst., vol. X. Abstract p. 6. 1879.

Bryozoum growing in thin expansions; celluliferous on one side (so far as observed), the other side marked by a wrinkled epitheca. Cell-tubes subcylindrical, oblique, enlarging to the aperture, extremely variable in size. Apertures from .5 to 1.5 millimeters in diameter, arching and subtriangular in form, and arranged in alternating and imbricating series; the larger cells frequently appearing polygonal and opening directly upward.

This species differs from *C. explanata* in the closer arrangement of the cells, comparatively little of the cell-tube being seen, and also in the larger cell-apertures, which open directly outward.

CERAMOPORA (PALESCHARA?) NOTHUS, *Hall.*

Ceramopora (*Paleschara?*) *nothus*, HALL. Trans. Alb. Inst. vol. X. Abstract p. 6. 1879.

Bryozoum growing in thin expansions, attached to other organic bodies; cell-tubes short, arranged in alternating and imbricating order; aperture arched or angular, usually oblique to the plane of the surface, sometimes opening obliquely upward, one-third of a millimeter in diameter. Surface marked by numerous slightly elevated maculæ, the centers of which are distant from each other about four or five millimeters. These maculæ are occupied by larger cells, their apertures being nearly half a millimeter in diameter.

In well-preserved specimens the angles of the cell-apertures have short, spine-like projections.

This species resembles *C. confluens;* but the cell-apertures are larger, and the maculæ are less elevated and always covered by cells. In *C. agellus* the cell-tubes are more exposed and have a radiating order not observed in this form.

CERAMOPORA? (LICHENALIA?) EXPLANATA. *Hall.*

Ceramopora? (*Lichenalia*) *explanata*, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 5. 1879.

Bryozoum consisting of thin foliate expansions, which may be free or incrusting, and celluliferous on one or both sides: when celluliferous on one side only, the lower side consists of a concentrically wrinkled epitheca; and when celluliferous on both sides, this epitheca becomes a thin diaphragm separating the two ranges of cells. Cellules obliquely ascending and rapidly expanding towards the aperture; arranged in alternating and imbricating series; apertures oblique to the surface of the frond, opening in an arched or subtriangular form.

This species occurs in moderately large expansions, presenting the general aspect of *Lichenalia concentrica;* but it may readily be distinguished by the angular form of the cell-apertures, and by the direction of the cells being more nearly parallel to the epitheca or diaphragm; and they are exposed for nearly their whole length.

ESCHAROPORA, *Hall.*

ESCHAROPORA (PTILODYCTIA) ANGUSTA, *Hall.*

Escharopora (*Ptilodyctia*) *angusta*, HALL. Trans. Alb. Inst. vol. x. Abstract p. 6. 1879.

Bryozoum an elongate, simple stipe, celluliferous on both sides: cell-apertures opening a little obliquely upon the surface, about five in the width of a stipe, occupying a width of 1.3 millimeters, while in the same space longitudinally there are three apertures. Margins of stipe granulose.

PALESCHARA, *Hall.*

PALESCHARA OFFULA, *Hall.*

Plate 7, Figs. 7, 8.

Paleschara offula, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 7, 8. 1876. Mus. ed., p. 120. 1879.

Bryozoum consisting of thin expansions attached to other organic bodies, one side being celluliferous; cellules polygonal, from five to seven-sided, varying from .25 to .50 mm. in diameter.

This species presents the usual character of the species of this genus, having wide, shallow polygonal cells which are larger than those of *P. maculata.* The specimens of this species, so far as known, present no maculæ of larger cells or of barren spaces.

PALESCHARA MACULATA, *Hall.*

Plate 7, *Figs.* 9–13.

Paleschara maculata, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 9, 10. 1876. Mus. edit., p. 121. 1879.
P.? aspera, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 11, 13. 1876.

Bryozoum a thin foliate expansion encrusting other organic bodies. Cells polygonal, contiguous, about three to four in the space of one millimeter, with maculæ of larger cells unequally distributed over the surface.

The cells appear to be arranged in somewhat concentrically radiating lines, and are longer in the direction of these lines, the length being sometimes twice as great as the width. In well-preserved specimens there are distinct short spinules at the angles of the cells.

The figures referred to *Paleschara? aspera*, on Plate 7, are representations of a phase of *P. maculata*, and the cell-apertures are incorrectly delineated.

PALESCHARA INCRASSATA, *Hall.*

Paleschara incrassata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 121. 1879.

Bryozoum occurring as thin, or more or less thickened, expansions encrusting other organic bodies. Cellules oval; apertures margined with coarse granulæ or spinules, and in specimens somewhat worn the cellules are separated by a distinct intercellular space or a thickening of the cell-walls.

This form is distinguished from *P. maculata* by the smaller oval cell-apertures, the thicker interspaces and coarser granulæ at the margins of the cells. It may be only a variety of that species possessing these distinctive features.

PALESCHARA? (CHÆTETES?) SPHÆRION, *Hall.*

Plate 7, *Figs.* 14, 15.

Paleschara? sphærion, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 8, figs. 14 and 15. 1876.
Paleschara? (Chætetes?) sphærion, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. edit., p. 121, pl. 8, figs. 14, 15. 1879.

Bryozoum incrusting or free, occurring in flattened, irregularly circular, or depressed hemispheric masses of one or two millimeters in thickness; in its more complete condition assuming a spheroidal hollow form. Cells polygonal, contiguous, about four in the space of 1 mm., with maculæ of larger cells, the centers of which are distant from each other about 4 mm.; the larger cells two or three times the size of the smaller ones.

In its mode of growth this form resembles CHÆTETES, but no specimens have been seen where the depth of the cells is more than 2 mms. The cell-apertures are somewhat more regularly hexagonal than in the preceding forms, and by this character it is readily distinguishable from *P. confluens.* This species is also distinguished from the latter by the character of the maculæ and the larger cells. In *P. maculata* the maculæ are less conspicuous, and the larger cells do not differ so much in size from the ordinary ones.

STICTOPORA, *Hall.*

The use of the generic term STICTOPORA is continued for branching forms of this character, where the cell-apertures are round or oval, or sometimes partially covered by a projecting lip; and where the intervening space may be plain or marked by slender carinæ, striæ or elevations separating the rows of cells. These fossils are not properly PTILODYCTIA, as claimed by some authors, the latter being simple non-branching stipes with cells of different character from those of STICTOPORA.

STICTOPORA SIMILIS, *Hall.*

Plate 10, *Figs.* 13–16.

Stictopora similis, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 13–16. 1876. Mus. edit. p. 122. 1879.
Compare *S. punctipora*, HALL. Pal. N. Y., vol ii, p. 157, pl. 40B, figs. 2*a*, 2*b*, 2*c*. 1852.

Bryozoum ramose, branches flattened, width from two to three millimeters; margins destitute of cells. Cell-apertures oval, opening directly outward, closely arranged in oblique rows; length .35 mm., width .18 to .25 mm.

This species differs from *S. orbipora*, occurring in the same locality, by its thinner branches and oval cell-apertures.

STICTOPORA ORBIPORA, *Hall.*

Stictopora orbipora, HALL. Trans. Alb. Inst. vol. x. Abstract p. 5. 1879.

Bryozoum ramose; bifurcations frequent, branches convex, thickness about half as great as the width; margins of branches destitute of cellules, and marked by granulose striæ. Cellules rising from a thin diaphragm and ascending at an angle of about 45° for half their length and then turning slightly backward, open upon the surface in small circular apertures which are surrounded by an elevated granulose margin: cellules arranged in oblique lines in which there are sixteen cell-apertures in the space of five millimeters.

This species differs from *S. similis* in the thicker stipe and the distinctly circular cell-apertures.

FENESTELLA, *Lonsdale.*

FENESTELLA AMBIGUA, *Hall.*

Plate 10, *Figs.* 17-21.

Hemitrypa dubia, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 17-21. 1876.
Fenestella ambigua, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 123, pl. 11, figs. 17-21. 1879.
Not *Fenestella dubia*, LONSDALE.

Bryozoum broadly funnel-form; branches, eight in the space of five millimeters; on the non-poriferous side regular and somewhat rigid in appearance, flattened, striated; striæ sharp, slightly sinuous and sometimes granulose, two to three on each branch. Dissepiments strong, frequently as wide as the branches, six in the space of 5 mm., expanding at their junction with the branches and on the same plane; striated on the non-poriferous side. Fenestrules oval to subcircular, from nearly equal to twice the width of the branches, and from one-third longer to nearly twice as long as wide.

Cell-apertures in two ranges, small, circular, separated from each other by a distance greater than the aperture, four in each fenestrule, opening nearly directly upward, with a distinctly elevated margin. Ranges of cellules separated by a thin partition which extends upward to an elevation equal to twice the thickness of the branch below, and then expanding laterally on each side, forms a pseudo-branch. These pseudo-branches are connected by dissepiments which arise from the upward growth and expansion of the narrow edges of the dissepiments below, in the same manner as in the branches proper, and the surface of both the pseudo-branches and dissepiments are striated as on the non-poriferous face. In well-preserved specimens there are rows of minute pits between the striæ. This accessory surface differs, however, in some degree from the non-poriferous face proper, in the apparently more sinuous character and irregularity of growth in branches and dissepiments, giving a different aspect to the fenestrules.

FENESTELLA PARVULIPORA, *Hall.*

Plate 11, *Figs.* 1-9.

Fenestella parvulipora, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 12, figs. 1-9. 1876. Mus. edit., p. 123. 1879.

Frond broadly funnel-shaped, and growing very luxuriantly; branches somewhat slender, from eight to ten in the space of five millimeters; bifurcations frequent and irregular. On the non-poriferous side branches rounded, marked with fine but distinct striæ, of which there are from five to seven on the width of the branch. Dissepiments slender, about one-third as wide as the branches, and expanding at their junction, rounded on the non-poriferous side and sharply angular or carinate on the poriferous side; five to seven in the space of 5 mm. Fenestrules subquadrangular or broadly oval, width varying from one-half to twice the width of the branches, length once and a half to twice the width. Cell-apertures in two ranges, generally four and sometimes five in the space of each fenestrule, circular or slightly oval, opening nearly directly upward; distance from each other less than the diameter of the aperture; margins distinctly elevated and slightly indenting the border of the fenestrule; space between the ranges of cellules carinated; carina sharp, elevated and nodose, the nodes in well-preserved specimens prominent, about fifteen in the space of 5 mm.

A characteristic of this species is the nodose carinæ, a feature not observed in any other species from this locality.

FENESTELLA ACMEA, *Hall.*

Plate 11, *Figs.* 10-14.

Fenestella acmea, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 12, figs. 10-13. 1876.

Fenestella sp.? HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 12, fig. 14. 1876.

Fenestella acmea, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. Edit. p. 124, pl. 12, figs. 10-14. 1879.

Compare *F. Nervia*, HALL. 26th Rep. N. Y. St. Mus. Nat. Hist., p. 93. 1874.

Bryozoum funnel-form, narrowly expanding below and spreading above, sides undulated. Branches rigid, eleven or twelve in the space of five millimetres; non-poriferous sides slightly rounded, longitudinally striated; striæ very strong and prominent, three or four in the width of the branch. Dissepiments about half the width of the branches as they appear on the non-poriferous side, about seven or eight in the space of 5 mm., expanding at their junction with the branches and transversely striated; on the poriferous side depressed and angular. Fenestrules broadly oval, a little wider than the branch, length from one and one-third to twice the width, appearing narrower and sometimes nearly obsolete on the poriferous side. Cell-apertures small, circular, in two ranges, distant from each other more than their diameter, opening nearly directly upward; margins distinctly elevated and indenting the border of the fenestrule. Space between the ranges of cells carinate, the carina thin and elevated, abruptly expanding on each side above, and again narrowing to a thin carina.

The elevated and expanded carina which is again carinate, and the partial closing of the fenestrules on the poriferous side are characteristics of this species.

The specimen, *Fenestella sp?* fig. 14, ut cit., proves to be identical with undoubted *Fenestella acmea*, and differs from *F. bellastriata* in its regular oval fenestrules, having a length never greater than twice the width, and eight to nine fenestrules in the space of 5 mm. In *F. bellastriata* there are six fenestrules in the space of 5 mm., and they have always a length greater than twice the width.

A small fragment of the poriferous side of the specimen figured presents the character of *F. acmea.*

FENESTELLA PUNCTOSTRIATA, *Hall.*

Plate 11, *Figs.* 15, 16.

Fenestella punctostriata, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 12, figs. 15, 16. 1876. Mus. edit., p. 125. 1879.

Frond flabelliform, branches strong, six in the space of .5 mm.; on non-poriferous side rounded, striated; striæ very distinct, five to ten on each branch, finely granulose. Dissepiments variable, sometimes slender, often thickened, and the branches sometimes anastomosing from lateral contact. Fenestrules variable in shape, width about the same as the branches, length from three to five times their width. Cell-pores in from three to five ranges, five or six pores in the length of a fenestrule. Apertures polygonal, contiguous and alternating, forming oblique rows across the branch; partitions thin, sharp and slightly granulose.

The poriferous side of the frond of this species was unknown at the time of giving the illustrations on plate 11. The study of many specimens shows that there is considerable variation in the fenestrules, which is not indicated in fig. 15. The striato-punctate character of the non-poriferous side, and the poriferous side with large angular cellules in more than two rows, are distinguishing features of the species.

FENESTELLA PERTENUIS, *Hall.*

Fenestella pertenuis, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 6. 1879.

Frond flabelliform, branches slender, from eight to eleven in the space of five millimeters; on the non-poriferous side the branches are flattened and striated, the striæ distinct, from three to five on a branch, and on well-preserved specimens finely granulose; dissepiments extremely slender, frequently oblique, and not expanding at their junction with the branches. Fenestrules quadrangular, varying from equal to twice the width of the branches, length from two to three times the width. Cell-pores in two ranges, apertures circular, four in the length of a fenestrule, opening obliquely upward; distance between the cell-apertures equal to, or a little less than, their diameter; margins slightly elevated. Center of the branch longitudinally carinated; carina sharp and slightly elevated.

FENESTELLA BELLASTRIATA, *Hall.*

Fenestella bellastriata, HALL. Trans. Alb. Inst., vol. x. Abstract p. 7. 1879.

Frond funnel-shaped, branches strong, rigid, very gradually enlarging to the bifurcation. Surface of non-poriferous side flattened, strongly striated, striæ two to three upon each branch except just below the bifurcation where the number is greater: dissepiments from one-half to two-thirds the width of the branches, expanded at their junction, about six in the space of five mm. Fenestrules elongate-oval, width about equal to that of the branches, length two or three times the width: cell-pores in two ranges, three in the length of each fenestrule, opening laterally, and slightly upward; margins elevated and indenting the border of the fenestrule. Center of the branch carinated, carina narrow and little elevated.

This species differs from *F. pertenuis*, in its stronger branches and much wider dissepiments, which are expanded at their junction with the branches, in the elongate-oval fenestrules, the strong sharp striæ on the non-poriferous side, and in the number of pores in the length of a fenestrule.

FENESTELLA CONFERTA, *Hall.*

Fenestella conferta, HALL. Trans. Alb. Inst., vol. x., Abstract p. 7, 1879.

Frond flabelliform, branches slender, about seven in the space of five millimeters; non-poriferous side rounded, striated; striæ granulose, four or five on the width of the branch; bifurcations very frequent and irregular; dissepiments from one-third to one-half the width of the branches, widening at their junction, usually direct but sometimes oblique, three in the space of five mm. Fenestrules subquadrangular, varying from equal to nearly double the width of the branches, length about three times the width. Cell-pores in from two to four ranges, usually three ranges; six to seven in the space of each fenestrule.

Where there are three or four ranges of cell-pores, the central range or ranges open directly upward, with the lateral ones opening nearly directly outward. Where there are but two ranges, they open directly outward. Cell-apertures small, circular, closely arranged and nearly contiguous; cell-margins but slightly elevated; margins and intermediate spaces finely granulose. Ranges of pores separated by a narrow nodose ridge.

FENESTELLA TANTULUS, *Hall.*

Fenestella tantulus, HALL. Trans. Alb. Inst., vol. x., Abstract, p. 8. 1879.

Frond flabelliform, branches straight, seven in the space of five millimeters; on the non-poriferous side rounded and striated; striæ fine, four to six on each branch, strongly granulose; dissepiments from one-half to two-thirds as wide as the branches, expanding at their junction, four in the space of five mm. Fenestrules elongate-oval or sub-quadrangular; width about the same as the branches, length from two to three times the width. Cell-pores in from two to four ranges, two ranges predominating; five pores in the length of a fenestrule; where there are more than two ranges the inner ones open directly upward and the lateral ones directly outward. Cell-apertures small, circular, margins slightly elevated, spaces between the ranges of apertures tortuously striated; where there are but two ranges of cells they open directly outward; the interspaces are elevated and nodose, but not carinated.

This may be distinguished from *F. conferta* by its smaller and more distant cell-apertures, and fewer cells in the space of a fenestrule, and by its stronger and more closely arranged dissepiments.

FENESTELLA PROLIXA, *Hall.*

Fenestella prolixa, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 8. 1879.

Frond flabelliform, branches slender, irregular near the base, becoming more regular and straighter above, eight or nine in the space of five millimeters; non-poriferous side rounded and striated; striæ sharp and in well-preserved specimens granulose, three or four upon each branch. Dissepiments very slender, occasionally oblique to the branch, slightly expanding at their junction, distant from each other about 1 mm. Fenestrules quadrangular, often twice the width of the branch, the length from two to two and a half times the width. Cell-pores in two ranges, four or five in the length of a fenestrule, opening nearly directly upward, apertures circular, margins distinctly elevated, granulose and indenting the border fenestrule; center of the branch carinated, carina sharp and strongly elevated.

THAMNISCUS, *King*.

THAMNISCUS NIAGARENSIS, *Hall*.

Plate 10, *Figs*. 22–25.

Thamniscus? Niagarensis, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 11, figs. 22–25. 1876.

Thamniscus Niagarensis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit. p. 126, pl. 11, figs. 22–25. 1879.

Bryozoum fruticose, often somewhat broadly funnel-shaped, numerous stems growing from a common base, bifurcating but not uniting laterally; branches much thickened below the bifurcations; celluliferous on the exterior side; non-celluliferous side striated; striæ strong, sinuous, often granulose, from three to five in the width of the branch; poriferous side frequently angular in the middle; cell-apertures contiguous, round, or polygonal from contact of the margins with each other, irregularly arranged, from fifteen to twenty-five millimeters in diameter.

This species occurs as a ramose frond rising from a single base, or spreading equally on all sides and broadly funnel-shaped. The poriferous sides of the branches are round or angular. No other species of the genus has been described from the Niagara formation.

CRINODEA.

SACCOCRINUS, *Hall*.

SACCOCRINUS CHRISTYI, *Hall*.

Plate 12, *Figs*. 12–20; *Plate* 15, *Figs*. 3, 4.

Actinocrinus Christyi, HALL. Trans. Alb. Inst., vol. iv, p. 196. Abstract, p. 2. May, 1863.

Not *Actinocrinus Christyi*, SHUMARD. 1st and 2d Rep. Geol. Surv. Mo., pt. ii. p. 191, pl. A, fig. 3. 1855.

Actinocrinus Whitfieldi, HALL. 20th Rep. N. Y. St. Cab. Nat. Hist., p. 326; Doc. edit., 1868.

Actinocrinus (*Saccorinus*) *Whitfieldi*, HALL. 20th Rep. N. Y. St. Cab. Nat. Hist., pp. 370, 430; Rev. edit. [1870.]

Saccocrinus Christyi (HALL) M. & W. Geol. Rep. Ill., vol. iii, p. 347, pl. 5, fig. 1. 1868.

Megistocrinus Marcouanus, W. & M. Mem. Bost. Soc. Nat. Hist., vol. i, p. 87, pl. 2, fig. 5. 1866.

Megistocrinus infelix, W. & M. Mem. Bost. Soc. Nat. Hist., vol. i, p. 110, pl. 11, fig. 7. 1866.

Saccocrinus Christyi, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 127, pl. 13, figs. 12, 20. 1879.

Body below the arms elongate, urn-shaped or subovate, very slightly spreading at the arm-bases. Basal plates proportionally small, more abruptly spreading than the succeeding plates, their lower margins somewhat produced near their junction with the column. First radial plates of moderate size, height and width equal, those of the postero-lateral rays smaller; second radial plates hexagonal, somewhat wider than high; third radials heptagonal, higher than wide, smaller than the second, supporting a pair of supraradials on each upper sloping side, one above the other, the upper one a bifurcating plate, and supporting a series of brachial plates on each upper side, giving four arms to each ray. Interradial plates numerous, the first one hexagonal, intermediate in size between the first and second radials, supporting two in the second and third ranges; about five other ranges above, of two or three plates each, gradually decreasing in size toward the summit. First anal plate heptagonal, equal in size to the largest first radial, but shorter, and supporting three smaller plates in the second range with a large number of smaller plates above. Intersupraradial spaces occupied by from five to seven plates each, which gradually decrease in size from below. The summit, in older specimens, is depressed convex, composed of a large number of polygonal plates, having near the anal side an aperture (or proboscis?) which is surrounded by smaller plates. The plates of the radial series are marked along their centers by an elevated ridge, which is interrupted at the sutures of the first, second and third radials, being a simple elongate node on the first radial, becoming more distinct in the supraradial series, and strongly elevated on the brachials; bifurcating on the fourth plate and again on the second above, with two or three plates of the brachial series above these, before the separation of the arms from the body.

Surface, in well-preserved specimens of the plates, toward their margins (except the horizontal faces of the direct radial series), marked by fine, sharply elevated radiating striæ, which cross the suture line uniting with similar ones on the adjacent plate; there are, likewise, sometimes, short ridges, or elongate nodes, radiating from near the margins of the interradial plates and uniting with similar ones on the adjacent plates. All the plates are marked by a finely granulose surface, the granulæ being arranged in concentric lines parallel to the margin of the plates. Column enlarging just before reaching the base of the cup, composed of very thin discs, which are coarsely granulose on their margins.

This species has some resemblance to *Actinocrinus* (*Saccocrinus*) *speciosus* (Pal. N. Y., vol. ii., p. 205, pl. 46, fig. 1), but differs in the proportional size and form of the plates, in the ridges of the radial series, and the bifurcation of the arms previous to, their separation from the body. (See Miller's Species and Remarks.)

PLATYCRINUS, *Miller.*

PLATYCRINUS SILURICUS, *Hall.*

Plate 15, *Fig.* 15.

Platycrinus siluricus. HALL. Trans. Alb. Inst., vol. x., Abstract p. 9, 1879.

The base of the calyx has been observed composed of large plates, which have a length of eleven millimeters, with a width of 10 mm. The plates are nearly flat in the middle, becoming convex toward the margins, and abruptly depressed at the suture line. Surface granulose, the granules elongate, tortuous and confluent.

MACROSTYLOCRINUS, *Hall.*

In the second volume of the Palæontology of New York, published in 1852. The name MACROSTYLOCRINUS was proposed for a crinoid having three basal plates, and five rays of three plates each, from which proceed the arms; the interradial series consisting of about five plates. In 1860, Dr. F. Roemer proposed the name CYTOCRINUS* for a crinoid of precisely the same structure and of similar form. The latter, though published eight years later, has the advantage of being a more euphonius name.

The genus CTENOCRINUS of Bronn, as described by Pictet, possesses a structure resembling, or identical with, CYTOCRINUS and MACROSTYLOCRINUS, though the exterior character is very distinctive; for the present the latter name is retained.

MACROSTYLOCRINUS STRIATUS, *Hall.*

Plate 12, *Figs.* 1–4.

Macrostylocrinus striatus, HALL. Trans. Alb. Inst., vol. iv, p. 207. Abstract, p. 13; May, 1863.

Macrostylocrinus striatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 129, pl. 13, figs. 1–4. 1879.

Body depressed turbinate: calyx, to the summit of the first radials, hemispheric in form. Rays from the second radials spreading; interradial spaces depressed or not expanding beyond the upper edge of the first radial plate; basal plates comparatively large; first radials large, prominent in the middle near the upper margins; second radials hexagonal, not half as large as the first, wider than high; third radials smaller than the second, petagonal, wider than high, supporting arm plates on the upper sloping sides; first interradials larger than the second radials, hexagonal, supporting two plates in the second range.

Surface finely and beautifully striated by fine, sharp, undulating striæ, about twelve of which traverse the lower side of the first radial plate, meeting similar ones from the basal plates; the apices or junction of the striæ are in the line from the center to the angles of the plates in the basal, first radial and interradial plates, while on the surface of the smaller plates these lines are sometimes broken into granules.

This species resembles the *M. ornatus* from the shale of the Niagara group at Lockport, N. Y.; but the rays are more spreading and the surface markings are finer.

**Silurische Fauna des Westlichen Tennessee*, p. 4, Tab. 4, figs. 2 a, 2 b and 2 c.

MACROSTYLOCRINUS STRIATUS, var. GRANULOSUS, *Hall.*

Macrostylocrinus striatus, var. *granulosus*, HALL. 28th Rep. N. Y., St. Mus. Nat. Hist.; Mus. edit., p. 129. 1879.

Among the collections from Waldron there is another species of this genus, or a constant variety, which presents a uniformly finely granulose surface. The prominent short ridge from the first radial which supports the arm is not so marked and is more angular. There is likewise a slight angularity of the body at the base of the radial plates, and the base of the calyx at its junction with the column is trilobate. The arms are long and slender and are not observed to bifurcate above the summit of the calyx. In a specimen having a height of calyx of five millimeters the length of the arms is 21 mm.

MACROSTYLOCRINUS FASCIATUS, *Hall.*

Plate 12, *Figs.* 5, 6.

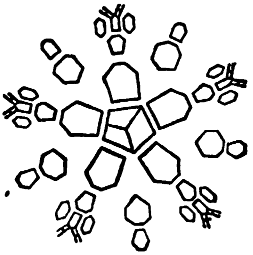
Cyathocrinus fasciatus, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 13, figs. 5, 6. 1876.

Macrostylocrinus fasciatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 130, pl. 13, figs. 5, 6. 1879.

Body rotund, calyx symmetrically cup-shaped; basal plates apparently three (not satisfactorily determined) closely anchylosed, and supporting five hexagonal first radial plates; upper sides of the first radials shortly truncated and supporting a small second radial, which in direct line supports a smaller one, from the upper sloping sides of which proceed two small arms. The first radial plates, on their adjacent sloping faces, support a heptagonal interradial plate, above and adjacent to which are three other interradials not fully determined.

Surface granulose-striate, the striæ sometimes in strong fascicles, to the almost entire exclusion of granulæ. Fascicles of striæ radiating from the basal plates to the margins of the plates above and uniting in a prominent stellate arrangement on the centers of the first radial plates. From the center of the first radial plates upward proceeds a distinct rounded ridge which extends to the third radial where it bifurcates to the arm plates.

Height of body to bifurcation of the arms 9-11 millimeter. Diameter of cup 7-8 mm. Column at base 1.5 mm.



The structure of the body above the base is that of the simplest form of ACTINOCRINUS, but without any distinctive feature of an anal side. The surface markings are characteristic of the species, and in some specimens the fasciculate striæ are raised into strong ridges of a more prominent character than those represented in the figure. In a single specimen observed the striæ are subdued and separated, with the interspaces marked by fine granulæ. The preceding diagram illustrates the structure so far as it has been observed.

Observations upon the genera GLYPTOCRINUS, GLYPTASTER, BALANOCRINUS *and* LAMPTEROCRINUS.

In the first volume of the *Palæontology of New York*, the genus GLYPTOCRINUS was proposed for a lower Silurian form, common in the blue shaly limestone of the Hudson River group at Cincinnati and elsewhere in the west. This genus is characterized by the presence of five basal or subradial plates, succeeded by five series of radial plates of three each, below the first subdivision of the ray. The column at its junction with the body is pentalobate. The genus has been recognized and several other species described by different authors. A careful examination of the basal cavity of some of the specimens gives indication that the last joint of the column may be divided, representing five undeveloped basal plates.

In the genus GLYPTASTER, five basal plates and five subradials are distinguished, with the rays consisting of three plates each, below the first subdivision.

The distinction between these genera is, therefore, as follows: In the first, the non-development of true basal plates, while the ray is twice subdivided before becoming free; and in the typical species the arms are not again subdivided. In the second, a moderate development of the true basal plates, with subradials above, while the ray is but once subdivided before becoming free.*

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* See illustrations of structure on pp. 206 and 207 of the 24th Rep. N. Y. St. Mus. Nat. Hist., 1872.

At the time of proposing the genus Glyptaster, the genus Balanocrinus of Troost was overlooked. The latter genus was recognized in the Wisconsin Report of 1860. Upon further examination, it appears that Balanocrinus of Troost has the structure of Glyptaster, with this exception, that the basal plates are much more fully developed, while the rays do not bifurcate before becoming free. Notwithstanding, therefore, the great similarity and near identity of structure in these forms, there seems good reason for the generic separation.

The genus Lampterocrinus of Roemer is identical with the genus Balanocrinus of Troost. The latter name was first published in Troost's Catalogue in 1849. The name Lampterocrinus was published in 1860, and in that year the genus Balanocrinus was recognized, and a species described (*B. inflatus*) from the Niagara group of Wisconsin.

The group of species referable to these genera is a very interesting one, and the following contribute some further information in relation to their geological distribution:

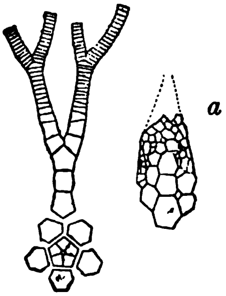

Fig. 1.

Diagram of *Glyptocrinus Nealli*, showing the basal and subradial plates, together with those of the ray to beyond the first bifurcation of the arms. *a* represents the size and arrangement of the plates of the anal area.

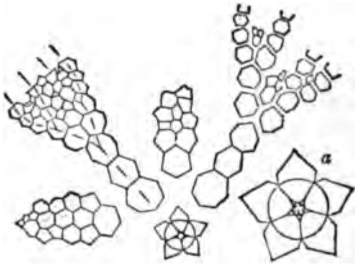

Fig. 2.

Diagram illustrating the structure of *G. decadactylus* showing that the basal plates are reduced to the smallest possible size. The plates of the ray to beyond the second bifurcation are all polygonal, and present a strong contrast to the corresponding portions of *G. Nealli.* *a* represents the basal and subradial plates enlarged to two diameters to show the minute basals.

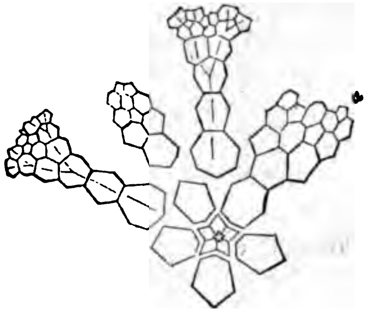

Fig. 3.

Diagram of *Glyptaster inornatus* showing the differences between this genus and *Glyptocrinus.* In this diagram the basal plates are seen to be of much larger size, and are visible beyond the circumference of the column; while the anal area *a* is larger than the interradial series, and is composed of a greater number of plates, the lower one of which truncates the subradial; while in *Glyptocrinus* the areas are similar to each other, and vary but slightly in the number and arrangements of the plates composing them.

GLYPTOCRINUS, *Hall.*

Glyptocrinus Carleyi, *Hall.*

Plate 13, *Figs.* 7-10; *Plate* 15, *Fig.* 5.

Glyptocrynus Carleyi, Hall. Trans. Alb. Inst., vol. iv. p. 203. Abstract, p. 9. May, 1863.

Glyptocrinus Carleyi, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 132, pl. 14, figs. 7-10. 1879.

General form of body pentangularly turbinate, having the angles coincident with the rays and marked by a rounded ridge, the intermediate spaces concave. The upper disc of the column is marked by five divisions indicating the undeveloped basal plates; subradial plates (basal plates of the generic description), wider than high, each one marked by a single or double rounded radiating ridge. Radial series strongly marked by a longitudinal rounded ridge, which bifurcates with the first and second division of the ray, giving from four to eight arms to each ray as it leaves the body. Besides the longitudinal ridge, the plates of the radial, inter-radial and supraradial series are marked by sharp radiating ridges, with the intermediate spaces finely granulose. Rays bifurcating on the third or fourth plate, and again on the second or third above, and on the sixth or seventh of the supraradial series. Interradial plates eight or more (probably ten or twelve), with many small intersupraradials.

Summit flat, depressed convex, or slightly concave, finely pustulose composed of numerous small plates. Proboscis (?) small, subcentral.

In form this species resembles the *G. decadactylus* of the Lower Silurian strata, but is proportionally shorter and a little more rapidly expanding. The radiating ridges upon the plates are thinner and sharper, and the intermediate spaces more strongly granulose. The column and arms are unknown.

GLYPTASTER, *Hall.*

GLYPTASTER OCCIDENTALIS, *Hall.*

Plate 12, *Figs.* 7-11.

Glyptaster occidentalis, HALL. Trans. Alb. Inst., vol. iv, p. 204. Abstract p. 10; May, 1863.

Glyptaster occidentalis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 133, pl. 13, figs. 7-11, 1879.

Body of medium size, broadly subturbinate; basal plates small, distinctly developed; subradial plates comparatively large, marked by a single rounded ridge which bifurcates in the middle of the plate, the divisions passing to the sutures of the radial plates. First radial plate large, the lower half marked by two rounded ridges which are continued from the two adjacent subradials, and unite on the middle of this plate, continuing along the second and third radials, and bifurcating on the latter, following the subdivisions of the ray. Interradials about three, with one interradial space (the anal) larger and containing a greater number of plates.

Surface of the ridge on the subradial and radial plates, marked by longitudinal striæ, while all the plates are marked by sharp radiating lines, which are continuous or interrupted and granulose, the granules being often arranged in more or less confluent lines; intermediate surface of plates granulose.

Column round above; arms unknown.

GLYPTASTER OCCIDENTALIS, var. CREBESCENS, *Hall.*

Glyptaster occidentalis, var. *crebescens*, HALL. 28th Rep. N. Y. St. Mus., Nat. Hist., Mus. edit., p. 133. 1879.

A specimen of somewhat more robust character than those described, has the ridges of the rays marked with undulating, subgranulose striæ, and the plates more distinctly striate, while the anal area is large and subventricose, showing three ranges of plates in the order of one, three and four, with a more numerous fourth range. The anterior ray gives some evidence of a second bifurcation before becoming free from the body.

GLYPTASTER INORNATUS, *Hall.*

Plate 13, *Figs.* 1-6.

Glyptaster inornatus, HALL. Trans. Alb. Inst., vol. iv, p. 205. Abstract p. 11; May, 1863.

Glyptaster inornatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 134, pl. 14, figs. 1-6. 1879.

Body somewhat urn-shaped, abruptly spreading at the base with the sides somewhat straight or moderately expanding; pentangular, the angles corresponding to the rays, and becoming ten-angled above the division of the rays. Basal plates much developed, distinctly pentangular, with the lower margins expanded and thickened, with a double or triple node on each one, and spreading beyond the column. Subradials large, six-sided except the one on the anal side which is seven-sided. First radials about equal in size to the subradials, heptagonal (as usual in the genus); second radials much smaller, quadrangular, and pentangular in the postero-lateral rays; third radials a little larger than the second, heptagonal. Supraradial series consisting of four or more plates before reaching the free arms, with an intersupraradial space which is occupied by five or more plates. First interradial plate octagonal, but little smaller than the first radial, and supporting two smaller plates in the second range, three in the third range, and several smaller plates above. On the anal side the first plate is octagonal, as large or larger than the first interradial plate, and resting on the heptagonal subradial plate, supporting four plates in the second range, with ten or twelve plates irregularly disposed above.

The subradial plates are prominent in the middle, with low undefined angular ridges extending to the sides of the plates, the intermediate spaces depressed. The ridges from the center to the upper sides of the plates are a little more prominent, and meet at the sutures with similar ridges on the lower sides of the first radials; these uniting on the center are continued in a stronger ridge along the center and following the subdivision become more prominent on the supraradial plates. The faces of the radial plates are marked by similar but less defined elevations extending to the sutures, and meeting similar ridges on the interradial plates. There are rarely some intermediate folds or undefined ridges upon the surface of the plates.

The surface has no peculiar markings. The column in its upper part is cylindrical, composed of unequal joints, which often appear to be made up of unequal or irregular plates.

This species differs from *G. occidentalis* and from *G. brachiatus* (*Pal. N. Y.*, vol. 2, p. 197) in the absence of surface sculpturing, nodes, or granules; in the greater development of basal plates, and the quadrangular form of the second radials.

CYATHOCRINUS, *Miller*.

CYATHOCRINUS POLYXO, *Hall*.

Plate 14, *Figs.* 10-17.

Cyathocrinus Polyxo, HALL. Trans. Alb. Inst., vol. iv. p. 199. Abstract, p. 5. May, 1863.

Cyathocrinus Polyxo, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 135, pl. 15, figs. 10-17. 1879.

Body broadly turbinate, base large and somewhat protuberant, sides angular from the prominence of the centers of the subradial and radial plates. Basal plates wider than high, the basal margins expanded at the junction with the column. Subradials large, wider than high; radials large, hexagonal, much wider than high, deeply notched on the upper margin; the articular scar is comparatively small and indenting the plate to about one-fourth of its depth. First anal plate quadrangular, nearly equal sided, resting upon two subradials, and supporting on one of its upper sides one end of the adjacent radial plate; second anal plate larger than the subradials, resting upon one subradial and the first anal, and between the radial plates of the adjacent rays.

The subradials, first radials and anal plates are prominent in the center, with low angular ridges extending to the sutures, the intermediate spaces being depressed, giving a strongly angular appearance to the cup. Entire surface smooth or very finely granulose. Summit, arms, and column unknown.

The body of this species is usually somewhat unsymmetrical from the anal side being more elongated or higher, and less ventricose than the other sides. The very large second anal plate, the protuberant base and large cicatrice for the column attachments, are distinguishing features of the calyx.

CYATHOCRINUS NUCLEUS, *Hall*.

Plate 14, *Figs*. 7-9.

Dendrocrinus nucleus, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 15, figs. 7-9. 1876.

Cyathocrinus nucleus, HALL. 28th Rept. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 136, pl. 15. figs. 7-9. 1879.

Body of medium size, depressed-turbinate, width one-fourth to one-third greater than the height, pentalobate in the upper part. Basal plates short, truncated below by the large column; subradial plates wider than high, three of them pentagonal and two heptagonal. First radial plates large, gibbous and projecting laterally so as to give a distinctly pentalobate aspect to the fossil; second radials much smaller than the first, wider than high, and separated by a small intercalated plate which rests upon the short sloping upper lateral faces of the first radials; third radials subpentagonal and supporting an arm upon each upper sloping face; arms (in part) bifurcating on the third plate, and above the last radial; anal plates two. Surface finely and strongly granulose.

The specimens vary from a height of 8 to 11.5 millimeters, with a diameter of 10 to 15 mm. The base of the column in the smallest measures 3.5 mm. and of the largest 5 mm. The column is proportionally very large and firmly inserted at the base, the upper plates are comparatively thin, and below these are alternations of thicker and thinner plates.

The figures given on plate 14 are from a young specimen, and do not fairly represent the species. The cicatrices on the radial plates are too narrow, and incorrectly represented as arm-bases. The species is not a DENDROCRINUS, but a true CYATHOCRINUS in structure.

CYATHOCRINUS (POTERIOCRINUS) ÆMULUS, *Hall.*

Cyathocrinus (Poteriocrinus) æmulus, HALL. **Trans. Alb. Inst., vol. x., Abstract, p. 10, 1879.**

Body pentangularly subturbinate, rapidly attenuate below the summit of the subradial plates, and expanded above; the anal side prominent. Basal plates with a prominent node at the base of each one: subradials higher than wide: radial plates wide, pentagonal, with the upper side deeply cicatrised for the arm attachment. First anal plate quadrangular, the second one large unequally pentagonal, and cicatrised on the upper side as in the radial plate. Surface granulose. Arms and column unknown.

This species differs from *C. Polyxo* of the same formation and locality, in its more elongate form and less robust character.

POTERIOCRINUS, *Miller.*

POTERIOCRINUS? CALYX, *Hall.*

Plate 15, *Fig.* 14.

Poteriocrinus? calyx, HALL. **Trans. Alb. Inst., vol. x, abstract, p. 10. 1879.**

Calyx turbinate. Basal plates strong, thickened at their lower margins, forming a distinct annulation at the base, and having a height a little less than half the height of the subradial plates; subradial plates elongate, three of them hexagonal, the anal side being unknown. Surface of the plates granulose.

The only specimen examined is imperfect and its full characters are unknown. The strong basal plates with the annulated lower margin, and the unusually elongated subradial plates are distinguishing features of the species, and present characteristic differences from any other species known in the formation.

LECANOCRINUS, *Hall.*

LECANOCRINUS PUSILLUS, *Hall.*

Plate 14, *Figs.* 1-6; *Plate* 15, *Fig.* 7.

Cyathocrinus pusillus, HALL. Trans. Alb. Inst., vol. iv, p. 200. Abstract p. 6; May, 1863.

C. pusillus, HALL. 20th Rep. State Cab. Nat. Hist. p. 324; Rev. edit. p. 366.

C. pusillus, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 15. 1876.

Lecanocrinus pusillus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. edit., p. 136, pl. 15, figs. 1-6. 1879.

Calyx small, forming a broad, shallow cup, a little inflated on the anal side. Basal plates very small, covered for nearly one-half their length by the column. Subradials proportionally large, three hexagonal and two larger and heptagonal. First radials short, broad, pentangular, the width twice the heighth; the second radial is a short plate having a width five times as great as the height, curving gently downward in the middle, and succeeded by a short pentangular plate supporting on its upper sloping sides a series of short linear arm plates; in some of the rays there is a second sub-division on the fourth plate above. First anal plate quadrangular, a little longer than wide, resting obliquely upon the two heptagonal subradials, and supporting upon its upper side one end of the adjoining first radial plate; the second anal plate, which is larger than the first, hexagonal, resting upon the top of a subradial and against the upper end of the first anal, supported on the sides by the first radial plates of the postero-lateral rays. Column small, round at its junction with the body. Entire surface finely granulose.

This species was originally described from the calyx, including the first radials, and its relations to LECANOCRINUS were not fully apparent. A more extensive collection from the locality has brought a considerable number of specimens in the same state as the one figured, including a single individual retaining the arms. In this condition its relations with the above genus are very apparent. The base is more spreading and more symmetrical than in the New York species of the genus, and the subdivision of the arms is likewise different. The form of the calyx corresponds to *Poteriocrinus pisiformis* of Roemer, from the Niagara group of Tennessee, but in the figure of that species there is no indication of an anal plate corresponding to the first anal plate of this fossil, though the figure is otherwise very similar.

ICHTHYOCRINUS, *Conrad.*

ICHTHYOCRINUS SUBANGULARIS, *Hall.*

Plate 15, *Figs.* 12, 13. *Plate* 16, *Figs.* 11-13.

Ichthyocrinus subangularis, HALL. Trans. Alb. Inst., vol. iv, p. 201. Abstract, p. 7; May, 1863.
I. subangularis, HALL. 20th Rep. St. Cab. Nat. Hist., p. 325, pl. 11, figs. 15, 16; pp. 367, 429, of Rev. edit. 1870.
I. subangularis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 137, pl. 16, figs. 11-13.
Compare *I. corbis* W. & M. Mem. Bost. Soc. Nat. Hist., vol. i, p. 89. 1865.

Body elongate, narrowly turbinate or obconic below, becoming cylindrical above, angular above the base by the prominence of the radial series; base truncate for the articulation of the rather large column. Basal plates rudimentary, concealed by the column. Subradial plates appearing pentangular from their junction with the column, somewhat higher than wide. The primary radial series consists of three plates each; the first one pentangular, with the upper angles slightly truncated; the second quadrangular; the third pentangular, supporting on its upper sides the first plates of the second radial series. The second radial series consists of ten ranges of rectangular plates, four to five in each range. The third radial series is composed of twenty ranges of narrow rectangular plates, seven to twelve in each range. The fourth radial series consists of forty ranges of similar plates, the number not having been observed; but no evidence of free arms is shown up to the eighth plate of the fourth series. No interradial plates have been observed. The plates are all emarginate at the center of the upper margins and correspondingly produced on the lower side, except the upper plate of each range which is produced at both margins. Surface of the radial plates elevated in the center; entirely smooth.

This character of the species, in the emargination of its plates, corresponds with that of the small patelloid plates of FORBESIOCRINUS, and in most respects it resembles that genus, except in the absence of interradial plates. This species differs from any other of the genus before described, in the narrowly turbinate form of the cup, the subangular outline of the basal portion, and the elongate cylindrical form of the upper part.

MELOCRINUS, *Goldfuss.*

MELOCRINUS OBCONICUS, *Hall.*

Plate 13, *Figs.* 11-14.

Melocrinus obconicus, HALL. Trans. Alb. Inst., vol. iv, p. 206. Abstract, p. 12; May, 1863.

M. obconicus, HALL. 28th Rep. N. Y. St. Mus. Nat Hist.; Mus. edit., p. 138, pl. 14, figs. 11-14. 1879.

Body narrowly subturbinate or obconical; basal plates forming together an elongate quadrangular prominence which scarcely expands above, and from which the body gradually enlarges to the base of the arms. Radial series of three plates each, the first of these heptagonal, and the largest plates in the body; second radials a little smaller than the first, octagonal; third radials much smaller, heptagonal and supporting on each upper sloping side a series of two supraradials, the upper one apparently a bifurcating plate in some of the rays.

The interradial series in three of the areas, are one, one and two or three, and in the other two areas one, two and three or four. The summit is pentalobate, covered by small plates, and showing the base of a slightly excentric proboscis. The plates of the body are smooth in the middle, with short, abrupt angular ridges near the margin, which meet similar ridges of the adjoining plates at the suture lines.

Height from the base to the summit but little more than half an inch, and greatest width at the arm bases about the same.

The genus TURBINOCRINUS of Troost differs from MELOCRINUS in having the first plate of one of the interradial spaces (or the first anal plate) truncating one of the basal plates, which does not occur in any known species of MELOCRINUS. The structure of TURBINOCRINUS above the basal plates is similar to ACTINOCRINUS, differing from that genus only in the presence of four basal plates.

RHODOCRINUS, *Miller.*

Subgenus LYRIOCRINUS, *Hall.*

LYRIOCRINUS MELISSA, *Hall.*

Plate 14, *Figs.* 18-27; *Plate* 15, *Fig.* 11.

Rhodocrinus Melissa, HALL. Trans. Alb. Inst., vol. iv, p. 198. Abstract, p. 4. May, 1863.

Rhodocrinus (Lyriocrinus) Melissa, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist. Mus. edit., p. 139, pl. 15, figs. 18-27. 1879.

Body depressed subspherical, or nearly hemispheric; base nearly flat or very depressed convex; central column cavity abruptly and deeply depressed; sides inflated in the lower part and contracted just below the arm-bases, where it is again a little expanded. Basal plates very small, concealed within the cavity and covered by the column. Subradial plates elongate heptagonal, their greatest width about one-third above their lower margin. Radial plates proportionally large; the first pentangular, wedge-form below; the second hexagonal, as large as the others; the third usually hexagonal (sometims pentagonal), supporting on the upper sloping faces one or two large supraradial plates, with a very small bifurcating or axillary plate resting in an excavation in the middle of the upper margin of the second, above which commence the arm plates; resting partly on this small plate, and partly on the second supraradial plate above the third radial, and, upon the upper margin of the latter, there is a somewhat large, heptagonal intersupraradial plate.

The interradial and anal series consist of four plates each; the first one heptagonal, as large as the radials or larger, supporting two somewhat smaller hexagonal plates in the second range, one still smaller in the third, above which the brachial plates of the adjacent rays unite; the anal series is the same as the interradial in the best formed specimens; but there is sometimes a slight irregularity seen in one series, which we infer may be the anal side. Surface of plates flat or with only the general convexity of the body, covered by very fine confluent granules or interrupted radiating striæ, which unite at the sutures; each subradial plate is marked at the middle of the lower margin with a small triangular node and a somewhat elevated rim, giving a pentalobate border to the basal cavity. In many specimens the first radial plate is marked by a central node.

Summit nearly flat and depressed toward the margins or to the inner side of the arm-bases, composed of numerous small polygonal plates, with a subcentral proboscis, and on the inner side of each pair of arms a foramen opening into the cavity of the body. Plates of the dome irregular in size and varying in different individuals, the specimen figured having larger plates than some others which have been subsequently observed.

Arms two from each ray, each one composed of short, wide pentagonal plates which are interlocking at their adjacent edges; plates gradually becoming shorter and the arms gradually tapering to their extremities. Length of arms about sixty-five millimeters, lateral diameter at the base 8 mm. Column round, not enlarging at its junction with the body, and uniformly cylindrical for some distance below; composed of thin plates, each fourth plate being thicker and armed with a row of strong nodes.

In general form and the symmetrical arrangement of plates, this species has much the appearance of EUCALYPTOCRINUS; but the subradial plates and greater number of interradials, and the absence of the elongate plates separating the pairs of arms as in that genus, are distinguishing characters. In the flatness of the plates, their peculiar surface markings, and their arrangement, this species differs from all others of the genus RHODOCRINUS described.

The relation of this species to *Lyriocrinus* [*Rhodocrinus*] *dactylus* of the Niagara formation in New York (Pal. N. Y., vol. ii, p. 197, plate 44) is very obvious, though there are differences which make it desirable to continue the specific distinction.

The difference between the species here noticed and the typical forms of RHODOCRINUS seem to warrant the continued use of the designation LYRIOCRINUS, at least as a subgeneric term.

DENDROCRINUS, *Hall.*

DENDROCRINUS ANCILLA, *Hall.*

Plate 15, *Fig.* 19.

Dendrocrinus ancilla, HALL. Trans. Alb. Inst., vol. x. Abstract. p. 9, 1879.

Body narrowly turbinate, width and height about as ten to twelve or as ten to thirteen; contracted between the arm-bases; upper part of the column closely adhering to the body, the five minute basal plates scarcely distinguishable from the segments of the column at its summit: subradial plates obscurely angular on the lower face, about three-fourths as wide as long, very gradually expanding in width from the base, and supporting on their upper adjacent sloping faces a large hexagonal interradial plate, and this supporting a single radial, from which the arms take their origin. Arms unknown.

This species is narrower and less robust than *D. longidactylus* (*Pal. N. Y.*, vol. ii. p. 193, plates 42 and 43).

LAMPTEROCRINUS, *Roemer*.

BALANOCRINUS, *Troost*.

LAMPTEROCRINUS PARVUS, *Hall*.

Plate 15, *Fig.* 6.

Lampterocrinus parvus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 9, 1879.

Body small, somewhat narrowly turbinate, obtuse at the base and obscurely pentagonal. Basal plates five, small; the subradials larger: radial plates comparatively larger and strong, the third one not determined: the first interradial nearly equal in size to the first radial; apparently two smaller plates above. Arm-bases prominent, giving a distinct pentalobate aspect to the body; the anal side extremely prominent.

This species has the essential structure and general aspect of *L. Tennessēnsis*, except that there are fewer plates in the interradial series, and the third radial plate is obscure. The specimen is much smaller than any of the Tennessee specimens which have come under my observation, having a height of only about ten millimeters.

From the limestone beds at Waldron.

EUCALYPTOCRINUS, *Goldfuss*.

EUCALYPTOCRINUS CRASSUS.

Plate 17, *Figs.* 1-11; *Plate* 18, *Figs.* 1-9; *Plate* 19, *Figs.* 2, 4, 5.

Eucalyptocrinus crassus, HALL. Trans. Alb. Inst., vol. iv, p. 197. Abstract, p. 3; May, 1863.

E. crassus, HALL. 20th Rep. St. Cab. Nat. Hist., p. 323, pl. 11, figs. 2, 3. Rev. edit., p. 365.

E. crassus, HALL. 28th Rept. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 141, pl. 17, figs. 1-11; pl. 18, figs. 1-9; pl. 19, figs. 2, 4, 5. 1879.

Body massive, turbinate from the base to the arms, and with the interbrachial plates and arms attached it has a general subovate form with a truncate base, which in most specimens is deeply impressed at the column attachment. Basal plates small concealed in the basal cavity. First radial plates much larger than the succeeding ones, height and width sub-equal;

second radials quadrangular, length and breadth equal, the greatest width at the base; third radials hexagonal, the lower lateral and upper sides shorter than the other three. First supraradials somewhat smaller than the third radials, pentangular in well formed specimens; second supraradials less than half as large as the first, pentangular, supporting on each upper sloping side a small triangular plate, upon which rest the first arm plates. The interradial plates are one large and two smaller to each field; the large one is ten-sided and elongate-ovate, its greatest width above the middle, the others are nearly as long, but narrow, united at their margins the entire length, the greatest width below the middle, the summits reaching as high as the fourth or fifth pair of arm plates. The intersupraradial plate is single, having the form of the two upper interradials when united, but smaller.

This species is extremely variable in form and proportions of the body, the older specimens being often more elongate, and sometimes constricted near the middle of the cup, giving a concavity to the sides. The base is much broader in some specimens, giving to the first radials a greater proportional breath. It differs from the *E. lævis* and *E. Phillipsi* of Troost, in the much greater height of cup, greater elongation of plates, and in having a less proportion of the first radial plates within the basal cavity.

A measurement of the calyx in some of the larger specimens gives a height of fifty millimeters, with a diameter across the top of 60 mm., and across the base of 27 mm. One specimen having a height of 50 mm., has a diameter at the base of 23 mm. One individual of more cylindrical form than usual has a height of 30 mm. with a diameter of the calyx at the summit of 28 mm. and a basal diameter of 16 mm. The figures 6, 7 and 8 of plate 17, and figures 1, 2, 4 and 6 of plate 18 are good illustrations of the prevailing forms of this adundant species.

EUCALYPTOCRINUS CONSTRICTUS, *Hall.*

Plate 15, *Fig.* 1.

Eucalyptocrinus constrictus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 10. 1879.

Body subturbinate, narrow below and abruptly expanding from the second radial plates; becoming ventricose and pentalobate above. Basal plates large, their entire characters undetermined. First radial plates wider than high, the lateral margins scarcely expanding, little incurved; indented on the lower margins for the reception of the basal plates, gently concave on the upper margin, the upper lateral angles truncated for the support of a large interradial plate with narrow base, the surface of which is moderately concave. The second and third radials are quadrangular and pentagonal; the summit of the latter reaching to the point of greatest gibbosity in the calyx, and supporting on the sloping sides the supraradial plates, being scarcely truncated at the upper extremity for the reception of the interbrachial plate. The double second interradial plate, surmounting the first interradial plate is distinctly concave, causing the lobed character of the upper part of the calyx. The lower plates of the arms, only, are preserved.

Surface of the plates smooth or finely granulose.

This species is conspicuously distinct from all others, in the contracted lower part of the calyx and the abrupt expansion, giving great gibbosity above, while it is contracted between the arms of each ray by the concavity of the double interradial plates.

EUCALYPTOCRINUS CÆLATUS, *Hall.*

Plate 15, *Fig.* 1; *Plate* 16, *Figs.* 1-10; *Plate* 19, *Figs.* 1, 3.

Eucalyptocrinus cœlatus, HALL. Pal. N. Y., vol. ii, p. 210, pl. 47, figs. 4*a*-4*e*. 1852.

E. cœlatus, HALL. Trans. Alb. Inst., vol. iv, p. 226. Abstract, p. 32; May, 1863.

E. cœlatus, HALL. 20th Rep. St. Cab. Nat. Hist., pp. 321, 329. Rev. edit. pp. 363, 366.

E. cœlatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 142, pl. 16, figs. 1-10; pl. 19, figs. 1, 3. 1879.

Body ovoid; base somewhat broadly truncate, and concave for the attachment of the column; calyx broadly cyathiform, shallow, height equal to one-third of the entire height of the body. Basal plates concealed in the cavity and covered by the summit of the column. Subradial plates strong, gently incurved at their basal margins which are covered by the column, thence expanding outward they are recurved above the middle, leaving the basal margins but little below the plane of the upper margins of the same plates. Second radial plates quadrangular, wider than high; third radials pentagonal, wider than high, and with the large ten-sided interradial plate, giving great expansion to the upper part of the calyx. Arm plates narrow in the lower part, but becoming gradually wider above, giving an elongate elliptical area between the solid interbrachial plates. Summit flat, depressed convex or slightly concave.

Column round, and near the summit composed of strong thick plates, with the margins projecting and rounded. Surface ornamentation always conspicuous and characteristic though subject to considerable variation. The plates of the body are covered with round, angular, or elongated nodes, and sometimes with straight or tortuous ridges often arranged in lines somewhat parallel to the margins of the plates. The younger specimens are much more strongly nodose than the older. The arms are usually marked by two parallel ranges of rounded nodes along the central part, while there is a range of smaller nodes on the exterior margins. These nodes are sometimes confluent, and appear as transverse ridges. The interbrachial plates are marked by two ranges of rounded or transversely elongated nodes.

Figures 4 and 8 of plate 16 exhibit the base and upper margins of a large individual. The largest specimen of the calyx observed has a diameter of fifty millimeters, with a height of twenty-five millimeters.

The distinguishing features of this species, as it occurs in the Waldron collections, are the general rotund ovoid form, broad spreading calyx, with about one-third the height of the first radials covered by the column; the arms stout and each pair in length about three to three and a half times their greatest width.

For diagram of structure of *E. cœlatus* see *20th Report on the State Cabinet of Natural History*, page 321; Revised edition, page 363.

E. tuberculatus, as described by Miller and Dyer is closely related to *E. cœlatus*, and no comparisons can be satisfactorily made before examining specimens of both forms. The two forms figured by them represent both *E. crassus* and *E. cœlatus*.

EUCALYPTOCRINUS OVALIS, *Troost*.

Plate 17, *Figs*. 12, 13.

Eucalyptocrinus ovalis, TROOST. Catalogue of Crinoidea. 1849.

Eucalyptocrinus ovatus (in error for *E. ovalis*). Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 17, figs. 12, 13. 1876.

E. ovalis, (*Troost*) HALL. 28th Rept. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 143, pl. 17, figs. 12, 13. 1879.

Body oval-ovoid, outline curved from base to summit; the calyx somewhat deeply cup-shaped, and having a height equal to two-thirds the height from the base of the arms to the summit. Basal plates covered by the column. First radial plates strong, the greater portion of their height visible exterior to the column; second and third radials wider than high. Arms attaining their full width near the base, and continuing of the same width to about the middle of their length, and thence gradually tapering to the summit. The solid interbrachial plates are narrow in the lower and middle part, and greatly expanded at the summit.

Column strong, composed of thick joints with rounded margins, alternating with an equal number of much thinner joints with flattened edges.

This species is identified with the *E. ovalis* of Troost, from a comparison of the original specimens, which in the better preserved individuals have the same form and proportions. It differs from the young of *E. crassus* in the regularly elliptical outline of the entire body, the curving of the sides of the calyx, the less incurvation of the first radial plates into the column cavity, which is proportionally smaller than in that species. It is also especially distinguished from both *E. cœlatus and E. crassus*, by the great expansion of the interbrachial plates upon the summit, if such features are to be regarded as of specific value.

Compare fig. 13 of plate 17, with figs. 5 and 7 of plate 16, and with figs. 5 and 7 of plate 18.

Roots of Eucalyptocrinus.

Plate 19, *Figs* 6–8; *and Plate* 20.

The condition of the ancient ocean bed in the region of country now occupied by central Indiana, was apparently one of the most quiet and sheltered situations known during the Silurian period, and life was as prolific as in any tropical region of the present day.

Large surfaces of the more calcareous layers are covered with numerous forms of Bryozoa and corals; and the abundant roots of Crinoidea, with the bases of the stems, still remain as they grew upon the muddy bottom, the roots penetrating the ancient deposit, or commencing their growth upon some other organic body, and not unfrequently upon the bodies of the same species, or others of the genus which have been overthrown, and the more fragile portions dismembered by the slow process of maceration in a quiet sea.

From what we know of the locality, it is quite certain that many thousands of the bodies of Eucalyptocrinus have been gathered from the strata within an area of a few hundred yards, and the roots of these bodies, to the number of many hundreds, have been collected and preserved. These organisms appear to have grown in great abundance and in close proximity, with their stems of only moderate length, and the whole aspect must have been like a garden of lilies or tulips.

The specimen figure 5 of plate 17 may serve as an example of the manner of growth. The illustration is from a young individual of *E. crassus*, lying horizontally upon the calcareous shale, the stem turned downward from the natural vertical position to a horizontal one, without breaking or dismemberment, and the rootlets still remaining as they grew, penetrating the calcareous sediment. The prolific condition of this ancient sea is shown from the fact that the stems of crinoids while still living have been overgrown by corals; and shells of Gasteropods, in their most perfect and unknown condition, are overgrown by Bryozoa and Articulata.

The specimen, figure 8 of plate 17, is an example of the base of Eucalyptocrinus, remaining apparently in precisely the original condition, with the rootlets penetrating the calcareous mud in which it grew. The figures 6 and 7 show the bases of columns and the rootlets of two strong individuals attached to the overturned calyx of a large *Eucalyptocrinus cœlatus*. In the vertical view there are visible two other roots of smaller very young individuals. In the lateral view, figure 7, the rootlets are broken off by the removal of the shale which embedded them, and it is here seen that a Bryozoan has encrusted the rootlet upon one side. These bases of columns and rootlets are also found attached to the shells of Platyostoma and Strophostylus, as well as upon the calyces of Crinoids.

One of the larger examples of these roots of Eucalyptocrinus is illustrated on plate 20. The extension of the rootlets in their finest fibres has been several inches greater than shown in the figure, and the entire extent was probably not less than ten inches. Portions of specimens sometimes occur where the rootlets are much more extended, becoming quite filiform, but rarely if ever traceable to their final extremities in consequence of the breaking or exfoliation of the shale.

The great numbers of these undisturbed roots and the finer rootlets, standing in the position in which they grew upon the sea-bottom, is one of the best evidences of the extremely quiet condition which prevailed during the slow deposition of these calcareous shales of the Niagara Group.

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the width of the plate below. First arm plate quadrangular, above which their character is unknown. Surface finely granulose. Column and arms unknown. Height of calyx 12 millimeters.

This species in its external form bears much resemblance to *Cyathocrinus Polyxo*, but it is less robust, more slender and more distinctly pentangular in the lower part, while the column attachment is proportionally smaller. Compared with the young of that species the basal plates are distinctly higher, and the same is true of the subradials; but a marked difference in the structure is shown in the number and form of the basal plates, —*C. Polyxo* having five short broad plates, while this species has three basals, two of these hexagonal and about as high as wide, and one pentagonal plate on the anal side which is much higher than wide.

STEPHANOCRINUS, *Conrad*.

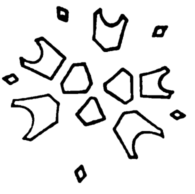
STEPHANOCRINUS GEMMIFORMIS, *Hall*.

Plate 13, *Figs*. 15, 20.

Stephanocrinus gemmiformis, HALL. Pal. N. Y., vol. ii, p. 215, pl. 48, fig. 2.
S. gemmiformis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 146, pl. 14, figs. 15, 20. 1879.

The details of the structure of the genus STEPHANOCRINUS, and of the species *S. gemmiformis*, are given in vol. 2 of Pal. N. Y., as cited above. The specimens figured on plate 13 of this Report are larger and more rotund than those usually occurring in the Niagara shales in New York, but other specimens from later collections at Waldron are of smaller dimensions, and show a range of variation in size and proportions, which clearly proves the identity of the Western forms with those of New York.

The structure of the calyx and the arrangement of parts in the summit and ambulacra appear to be identical with CODASTER, and a small smooth form in the same association, referred to that genus, has the same structure as the fossils under consideration.



STEPHANOCRINUS GEMMIFORMIS.

CODASTER, *McCoy.*

CODASTER (STEPHANOCRINUS?) PULCHELLUS, *Miller & Dyer.*

Plate 15, *Figs.* 8-10.

Codaster pulchellus, MILLER & DYER. Contributions to Palæontology, Journal of the Cincinnati Society of Natural History, April, 1878.
Codaster [*Stephanocrinus?*] *pulchellus*, (MILLER & DYER), HALL. Trans. Alb. Inst., vol. x. Abstract, p. 12, 1879.

Body obconical, triangular below, becoming obtusely pentagonal above, the angles coinciding with the ambulacral areas; the exterior surface between these being flat or slightly concave in the upper part. The basal plates constitute a little more than one-third the entire height of the body: plates of the second range much larger than the basal, and deeply indented on their upper margin for the reception of the ambulacra: plates of the third range extremely minute except on the anal ? side, where the terminal plate broadly truncates the upper sides of the two adjacent plates of the second range. Central aperture conspicuous, pentalobate. Surface obscurely striated.

In the specimens examined, the minute plates covering the central aperture are wanting. The grooves for the attachment of the tentaculæ are distinctly preserved, but no appendages have been seen.

This form differs from *Stephanocrinus gemmiformis* in its narrower proportions and more acute base, and also in the smaller and less elevated plates of the third series, of which one plate is conspicuously larger than the others.

In the structure of the body, at least, there are no differences which appear to be of generic importance between STEPHANOCRINUS and CODASTER. The species under consideration presents all the essential features of the former genus.

CODASTER PENTALOBUS, *Hall.*

Plate 15, *Fig.* 16.

Codaster pentalobus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 13, 1879.

Body robust, distinctly pentangular and pentalobate in the upper part, narrowing below; the basal portion unknown. Summit broad, the ambulacral areas prominent.

The specimen described has a width of over ten millimeters in the upper part; and the width of each side, measured from the base of the ambulacral areas, is about 7 mm.

A single imperfect specimen only, has been observed, but its characters are quite distinctive, when compared with any Silurian forms of the genus.

CALCEOCRINUS, *Hall.*

Calceocrinus, HALL. Pal. N. Y., vol. ii, p. 352, pl. 85, figs. 5, 6. 1852.
Cheirocrinus, HALL. 13th Rep. St. Cab. Nat. Hist., p. 122. 1860.

The following diagrams illustrate the generic structure:

Fig. 1 has the general form and proportions of plates shown in *C. stigmatus* of Plate 19. Fig. 2 shows a different proportion of the parts.

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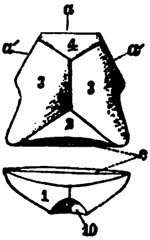
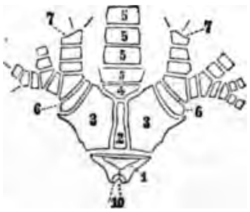


CALCEOCRINUS TUNICATUS.

2



CALCEOCRINUS CHRYSALIS.

Fig. 1—The basal plate with a cicatrix for the column attachment 10; 2 the dorso-basal plate; 3 3 the dorso-lateral plates; 4 the dorso-radial plate; *a* the face of attachment for the dorsal arms; *a a* faces of attachment for the lateral arms; *c* the faces of attachment for the strong ligament between the basal and lower dorsal plates.

Fig. 2—Has the same general structure, except that the dorsal plate 2 is narrow and elongate; 3 4 and 10 have the same significance as in Fig. 1; 5 5 5 5 are plates of the dorsal arm; 6 6 lateral brachial plates; 7 7 the lateral arms and their subdivisions.

CALCEOCRINUS STIGMATUS, *Hall.*

Plate 19, *Figs.* 9-11.

Cheirocrinus stigmatus, HALL. Trans. Alb. Inst, vol. iv, p. 225. Abstract, p. 31; 1862.
Calceocrinus stigmatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit. p. 147, pl. 19, figs. 9-11, 1879.

In the collections observed, this species is illustrated by the basal portions of the body, some fragments of the arms, and a single specimen which preserves the basal plate of the dorsal arm. The dorso-lateral plates are so closely anchylosed that no line of separation is observable, and the same is often true of the dorso-radial plate and the second or lower dorsal plate, which bears upon its lower margin the cicatrices for the ligamental attachment of the basal plate. The cicatrices for the three sets of arms are well preserved.

The species differs from any other known in the closely anchylosed condition of the dorso-lateral plates, which also involves the lower dorsal plate. The surface is marked by fine granulæ or undulating and tortuous granulose striæ.

BRACHIOPODA.

CRANIA, *Lamarck.*

CRANIA SILURIANA, *Hall.*

Plate 21, *Figs.* 3-7.

Crania Siluriana, HALL. Trans. Alb. Inst., vol. iv, p. 208. Abstract, p. 14; May 1863.

C. Siluriana, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 148, pl. 21, figs. 3-7. 1879.

Compare *Crania Siluriana*, DAVIDSON. "British Brachiopoda," Part vii, No. 1, pl. 8, figs. 19, 20. 1866.

Shell subcircular or transverse, very depressed-conical, apex excentric, slightly curved, situated one-third the diameter of the shell from the cardinal border. Exterior surface of upper valve smooth, with concentric lines of growth. Ventral or lower valve consisting of little more than a thickened rim, deeply marked on the cardinal margin by the somewhat large, distinct, posterior adductor muscular scars; the substance within the thickened border, not sufficient to preserve the muscular or vascular markings.

Transverse diameter of full grown specimens nearly twenty millimeters; height of upper valve of the same a little less than 6 mm. Where well preserved the surface is minutely granulose or subpunctate.

This species is usually found adhering to other fossils which are in a more or less dilapidated condition; showing that the Craniæ became attached after the death of the individuals on which they are found.

CRANIA SETIFERA, *Hall.*

Plate 21, *Figs.* 8-10.

Crania setifera, HALL. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.
C. setifera, HALL. 28th Rep. N. Y. St. Mus Nat. Hist., Mus. edit., p. 148, pl. 21, figs. 8-10. 1879.
(In error) *C. setigera* HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 21, figs. 8-10. 1876.

Shell circular, depressed-convex, apex central or slightly excentric, small, pointed or mammiform. Surface of upper valve closely covered with minute setiform spines, directed from the apex toward the margin. Ventral or lower valve with the exterior portion merely a calcareous ring, and the central area without any decided character.

When the setæ are removed, the surface appears strongly punctate, a character which distinguishes this form from *C. Siluriana.*

CRANIA SPINIGERA, *Hall.*

Plate 27, *Fig.* 1.

Crania spinigera, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 13. 1879.

Shell very broadly oval, wider than long, slightly concave on the margin near the apex. Upper valve depressed subconical, apex transversely subcentral, distant from the concave margin about one-third of the longitudinal diameter. Lower or ventral valve not observed.

Surface marked by very fine, sharp, lamellose, concentric striæ. Entire surface minutely papillose. Shell ornamented with irregular, interrupted radiating lines or ridges of small, short, tubular spines, diverging from the apex to the margins, and increasing in number by implantation only. These radiating lines are composed of a single row of imbricating spines forming a nearly continuous nodose ridge. The specimen described has over thirty of these rows at the margin.

When in a perfect condition the spines do not show their tubular character, being closed at the extremities. The individual is attached to the dorsal valve of *Rhynchonella Stricklandi*, and exhibits the plications of that shell continued over the CRANIA in corresponding folds, irrespective of the surface ornaments.

From *C. setifera* and *C. Siluriana*, with which it is associated, and from any other palæozoic form known, this species is distinguished by the radiating rows of spines.

LINGULA, *Bruguiere*.

LINGULA GIBBOSA, *Hall*.

Plate 27, *Fig.* 2.

Lingula gibbosa, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 13. 1879.

General form subelliptical, lateral margins curving, rounded at the base, and somewhat abruptly contracting towards the beak; valves gibbous on the umbones; greatest convexity at about one-third the length from the apex. Surface marked by fine irregular concentric striæ, which in some parts become lamellose, and also by concentric undulations.

PHOLIDOPS, *Hall*.

PHOLIDOPS OVALIS, *Hall*.

Plate 21, *Figs.* 1, 2.

Pholidops ovalis, HALL. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.

P. ovalis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 149, pl. 21, figs. 1, 2. 1879.

Shell round-oval, somewhat broader anterior to the middle; valves equally convex; apex situated about one-third the length of the shell from the posterior end. Surface marked by concentric lines of growth, which are strongly lamellose toward the margin.

This species differs from *P.* (*Orbicula*) *squamiformis* of the Niagara group of New York, in the greater convexity, more closely arranged concentric lines of growth, and in being more regularly and broadly oval. Rare.

ORTHIS, *Dalman*.

ORTHIS HYBRIDA, *Sowerby*.

Plate 21, *Figs.* 18–25.

Orthis hybrida, (Sow.) MURCH. Sil. Syst., p. 630, pl. 13, fig. 11. 1839.

Orthis hybrida, (Sow.) HALL. Pal. N. Y., vol. ii, p. 253, pl. 52, figs. 4*a*–4*o*. 1852.

Orthis hybrida? (Sow.) HALL. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.

Orthis hybrida, (Sow.) HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 149, pl. 21, figs. 18–25. 1879.

General form lenticular, or depressed spheroidal, wider than long; valves nearly equal, the ventral one depressed from the center to the base, while the dorsal valve is regularly convex, sometimes with a slight depression in the center near the beak; beaks almost equally elevated, the ventral one being scarcely incurved; hinge-line much shorter than the width of the shell; surface marked by thin sharp dichotomous striæ, which are arched upwards upon the sides and hinge-margin. Surface marked by radiating striæ crossed by extremely fine concentric striæ.

This species is readily distinguished by the near equality of the valves, one of which has a broad undefined depression along the center. The surface characters are very similar to *O. elegantula*, but the form of the shell, or of the separated valves, is quite sufficient to distinguish it.

This species is very common in the Waldron locality. The numerous specimens examined can be easily separated into two distinct varieties, one of them narrow and ventricose, with the anterior margins thickened and strongly lamellose, presenting strong varices of growth; another, broader and less ventricose, with sometimes a wide sinuosity in front. Few of the specimens have the broad sinuosity of the ventral valve and ventricose upper portion of the shell, so characteristic of the New York species which has been referred to *O. hybrida.*

ORTHIS ELEGANTULA, *Dalman.*

Plate 21, *Figs.* 11-17.

For *Synonymy*, see Pal. N. Y., vol. ii, p. 252. 1852.

Shell semi-oval; dorsal valve nearly or quite flat, sometimes with a depression along the centre; ventral valve very convex, extremely elevated towards the beak, which is much extended and incurved over the area; hinge-line shorter than the width of the shell; area narrow not extending to the extremities of the hinge-line. Surface ornamented with fine radiating striæ, which are dichotomous towards the margin and arched towards the hinge-line. In the better preserved specimens, the diverging striæ are crossed by very fine concentric striæ.

to two-thirds the height from the base of the arms to the summit. Basal plates covered by the column. First radial plates strong, the greater portion of their height visible exterior to the column; second and third radials wider than high. Arms attaining their full width near the base, and continuing of the same width to about the middle of their length, and thence gradually tapering to the summit. The solid interbrachial plates are narrow in the lower and middle part, and greatly expanded at the summit.

Column strong, composed of thick joints with rounded margins, alternating with an equal number of much thinner joints with flattened edges.

This species is identified with the *E. ovalis* of Troost, from a comparison of the original specimens, which in the better preserved individuals have the same form and proportions. It differs from the young of *E. crassus* in the regularly elliptical outline of the entire body, the curving of the sides of the calyx, the less incurvation of the first radial plates into the column cavity, which is proportionally smaller than in that species. It is also especially distinguished from both *E. cælatus and E. crassus*, by the great expansion of the interbrachial plates upon the summit, if such features are to be regarded as of specific value. Compare fig. 13 of plate 17, with figs. 5 and 7 of plate 16, and with figs. 5 and 7 of plate 18.

Roots of EUCALYPTOCRINUS.

Plate 19, *Figs* 6–8; *and Plate* 20.

The condition of the ancient ocean bed in the region of country now occupied by central Indiana, was apparently one of the most quiet and sheltered situations known during the Silurian period, and life was as prolific as in any tropical region of the present day.

Large surfaces of the more calcareous layers are covered with numerous forms of Bryozoa and corals; and the abundant roots of Crinoidea, with the bases of the stems, still remain as they grew upon the muddy bottom, the roots penetrating the ancient deposit, or commencing their growth upon some other organic body, and not unfrequently upon the bodies of the same species, or others of the genus which have been overthrown, and the more fragile portions dismembered by the slow process of maceration in a quiet sea.

From what we know of the locality, it is quite certain that many thousands of the bodies of Eucalyptocrinus have been gathered from the strata within an area of a few hundred yards, and the roots of these bodies, to the number of many hundreds, have been collected and preserved. These organisms appear to have grown in great abundance and in close proximity, with their stems of only moderate length, and the whole aspect must have been like a garden of lilies or tulips.

The specimen figure 5 of plate 17 may serve as an example of the manner of growth. The illustration is from a young individual of *E. crassus*, lying horizontally upon the calcareous shale, the stem turned downward from the natural vertical position to a horizontal one, without breaking or dismemberment, and the rootlets still remaining as they grew, penetrating the calcareous sediment. The prolific condition of this ancient sea is shown from the fact that the stems of crinoids while still living have been overgrown by corals; and shells of Gasteropods, in their most perfect and unknown condition, are overgrown by Bryozoa and Articulata.

The specimen, figure 8 of plate 17, is an example of the base of Eucalyptocrinus, remaining apparently in precisely the original condition, with the rootlets penetrating the calcareous mud in which it grew. The figures 6 and 7 show the bases of columns and the rootlets of two strong individuals attached to the overturned calyx of a large *Eucalyptocrinus cælatus*. In the vertical view there are visible two other roots of smaller very young individuals. In the lateral view, figure 7, the rootlets are broken off by the removal of the shale which embedded them, and it is here seen that a Bryozoan has encrusted the rootlet upon one side. These bases of columns and rootlets are also found attached to the shells of Platyostoma and Strophostylus, as well as upon the calyces of Crinoids.

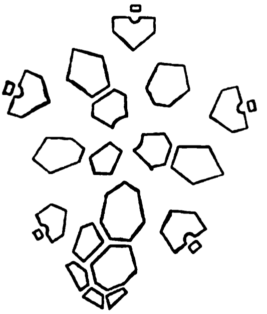
One of the larger examples of these roots of Eucalyptocrinus is illustrated on plate 20. The extension of the rootlets in their finest fibres has been several inches greater than shown in the figure, and the entire extent was probably not less than ten inches. Portions of specimens sometimes occur where the rootlets are much more extended, becoming quite filiform, but rarely if ever traceable to their final extremities in consequence of the breaking or exfoliation of the shale.

The great numbers of these undisturbed roots and the finer rootlets, standing in the position in which they grew upon the sea-bottom, is one of the best evidences of the extremely quiet condition which prevailed during the slow deposition of these calcareous shales of the Niagara Group.

AMPHERISTOCRINUS, *Hall.*

Body turbinate, composed of the following series of plates: basal plates three; subradials five; radials five in the first series, anal area composed of several plates; arms unknown.

This crinoid has the general form and aspect of POTERIOCRINUS, or CYATHOCRINUS, and has a similar structure above the basal series. Three individuals have been examined, each one of which has the remarkable protuberant attenuate base and large anal area.



The accompanying diagram gives an illustration of the structure of the genus.

AMPHERISTOCRINUS TYPUS, *Hall.*

Plate 15, *Figs.* 17, 18.

Ampheristocrinus typus, HALL. Trans. Alb. Inst., vol. x, Abstract, p. 11. 1879.

Body somewhat angularly turbinate, base a little protuberant for the column attachment, narrow and distinctly pentangular above to the middle of the subradial plates; the areas formed by the lateral portions of the adjacent subradials, the basal portion of the radials and upper part of the basal plates, are distinctly flattened or sometimes slightly concave; and in like manner the areas formed by the lateral portions of adjacent radial plates and the upper part of the subradials are distinctly flattened. The pentagonal basal plate is higher than wide, the other two wider than high. Subradials with the pentagonal form a little higher than wide and the others about equal in height and width. Radials fully one-third wider than high, with a narrow cicatrix upon the upper margin for the attachment of the brachial plate, which occupies scarcely one-third of the width of the plate below. First arm plate quadrangular, above which their character is unknown. Surface finely granulose. Column and arms unknown. Height of calyx 12 millimeters.

This species in its external form bears much resemblance to *Cyathocrinus Polyxo*, but it is less robust, more slender and more distinctly pentangular in the lower part, while the column attachment is proportionally smaller. Compared with the young of that species the basal plates are distinctly higher, and the same is true of the subradials; but a marked difference in the structure is shown in the number and form of the basal plates, —*C. Polyxo* having five short broad plates, while this species has three basals, two of these hexagonal and about as high as wide, and one pentagonal plate on the anal side which is much higher than wide.

STEPHANOCRINUS, *Conrad.*

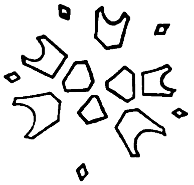
STEPHANOCRINUS GEMMIFORMIS, *Hall.*

Plate 13, *Figs.* 15, 20.

Stephanocrinus gemmiformis, HALL. Pal. N. Y., vol. ii, p. 215, pl. 48, fig. 2.
S. gemmiformis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 146, pl. 14, figs. 15, 20. 1879.

The details of the structure of the genus STEPHANOCRINUS, and of the species *S. gemmiformis*, are given in vol. 2 of Pal. N. Y., as cited above. The specimens figured on plate 13 of this Report are larger and more rotund than those usually occurring in the Niagara shales in New York, but other specimens from later collections at Waldron are of smaller dimensions, and show a range of variation in size and proportions, which clearly proves the identity of the Western forms with those of New York.

The structure of the calyx and the arrangement of parts in the summit and ambulacra appear to be identical with CODASTER, and a small smooth form in the same association, referred to that genus, has the same structure as the fossils under consideration.



STEPHANOCRINUS GEMMIFORMIS.

CODASTER, *McCoy*.

CODASTER (STEPHANOCRINUS?) PULCHELLUS, *Miller & Dyer*.

Plate 15, *Figs*. 8-10.

Codaster pulchellus, MILLER & DYER. Contributions to Palæontology, Journal of the Cincinnati Society of Natural History, April, 1878.

Codaster [*Stephanocrinus?*] *pulchellus*, (MILLER & DYER), HALL. Trans. Alb. Inst., vol. x. Abstract, p. 12, 1879.

Body obconical, triangular below, becoming obtusely pentagonal above, the angles coinciding with the ambulacral areas; the exterior surface between these being flat or slightly concave in the upper part. The basal plates constitute a little more than one-third the entire height of the body: plates of the second range much larger than the basal, and deeply indented on their upper margin for the reception of the ambulacra: plates of the third range extremely minute except on the anal ? side, where the terminal plate broadly truncates the upper sides of the two adjacent plates of the second range. Central aperture conspicuous, pentalobate. Surface obscurely striated.

In the specimens examined, the minute plates covering the central aperture are wanting. The grooves for the attachment of the tentaculæ are distinctly preserved, but no appendages have been seen.

This form differs from *Stephanocrinus gemmiformis* in its narrower proportions and more acute base, and also in the smaller and less elevated plates of the third series, of which one plate is conspicuously larger than the others.

In the structure of the body, at least, there are no differences which appear to be of generic importance between STEPHANOCRINUS and CODASTER. The species under consideration presents all the essential features of the former genus.

CODASTER PENTALOBUS, *Hall*.

Plate 15, *Fig*. 16.

Codaster pentalobus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 13, 1879.

Body robust, distinctly pentangular and pentalobate in the upper part, narrowing below; the basal portion unknown. Summit broad, the ambulacral areas prominent.

The specimen described has a width of over ten millimeters in the upper part; and the width of each side, measured from the base of the ambulacral areas, is about 7 mm.

A single imperfect specimen only, has been observed, but its characters are quite distinctive, when compared with any Silurian forms of the genus.

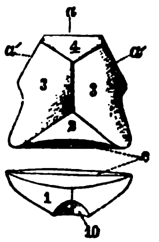
CALCEOCRINUS, *Hall.*

Calceocrinus, HALL. Pal. N. Y., vol. ii, p. 352, pl. 85, figs. 5, 6. 1852.
Cheirocrinus, HALL. 13th Rep. St. Cab. Nat. Hist., p. 122. 1860.

The following diagrams illustrate the generic structure:

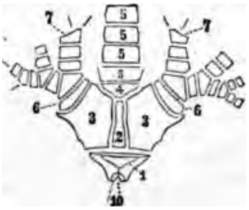
Fig. 1 has the general form and proportions of plates shown in *C. stigmatus* of Plate 19. Fig. 2 shows a different proportion of the parts.

1



CALCEOCRINUS TUNICATUS.

2



CALCEOCRINUS CHRYSALIS.

Fig. 1—The basal plate with a cicatrix for the column attachment 10; 2 the dorso-basal plate; 3 3 the dorso-lateral plates; 4 the dorso-radial plate; *a* the face of attachment for the dorsal arms; *a a* faces of attachment for the lateral arms; *c* the faces of attachment for the strong ligament between the basal and lower dorsal plates.

Fig. 2—Has the same general structure, except that the dorsal plate 2 is narrow and elongate; 3 4 and 10 have the same significance as in Fig. 1; 5 5 5 5 are plates of the dorsal arm; 6 6 lateral brachial plates; 7 7 the lateral arms and their subdivisions.

CALCEOCRINUS STIGMATUS, *Hall.*

Plate 19, *Figs.* 9-11.

Cheirocrinus stigmatus, HALL. Trans. Alb. Inst, vol. iv, p. 225. Abstract, p. 31; 1862.
Calceocrinus stigmatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit. p. 147, pl. 19, figs. 9-11, 1879.

In the collections observed, this species is illustrated by the basal portions of the body, some fragments of the arms, and a single specimen which preserves the basal plate of the dorsal arm. The dorso-lateral plates are so closely anchylosed that no line of separation is observable, and the same is often true of the dorso-radial plate and the second or lower dorsal plate, which bears upon its lower margin the cicatrices for the ligamental attachment of the basal plate. The cicatrices for the three sets of arms are well preserved.

The species differs from any other known in the closely anchylosed condition of the dorso-lateral plates, which also involves the lower dorsal plate. The surface is marked by fine granulæ or undulating and tortuous granulose striæ.

BRACHIOPODA.

CRANIA, *Lamarck.*

CRANIA SILURIANA, *Hall.*

Plate 21, *Figs.* 3-7.

Crania Siluriana, HALL. Trans. Alb. Inst., vol. iv, p. 208. Abstract, p. 14; May 1863.

C. Siluriana, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 148, pl. 21, figs. 3-7. 1879.

Compare *Crania Siluriana*, DAVIDSON. "British Brachiopoda," Part vii, No. 1, pl. 8, figs. 19, 20. 1866.

Shell subcircular or transverse, very depressed-conical, apex excentric, slightly curved, situated one-third the diameter of the shell from the cardinal border. Exterior surface of upper valve smooth, with concentric lines of growth. Ventral or lower valve consisting of little more than a thickened rim, deeply marked on the cardinal margin by the somewhat large, distinct, posterior adductor muscular scars; the substance within the thickened border, not sufficient to preserve the muscular or vascular markings.

Transverse diameter of full grown specimens nearly twenty millimeters; height of upper valve of the same a little less than 6 mm. Where well preserved the surface is minutely granulose or subpunctate.

This species is usually found adhering to other fossils which are in a more or less dilapidated condition; showing that the Craniæ became attached after the death of the individuals on which they are found.

CRANIA SETIFERA, *Hall.*

Plate 21, *Figs.* 8–10.

Crania setifera, HALL. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.
C. setifera, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 148, pl. 21, figs. 8–10. 1879.
(In error) *C. setigera* HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 21, figs. 8–10. 1876.

Shell circular, depressed-convex, apex central or slightly excentric, small, pointed or mammiform. Surface of upper valve closely covered with minute setiform spines, directed from the apex toward the margin. Ventral or lower valve with the exterior portion merely a calcareous ring, and the central area without any decided character.

When the setæ are removed, the surface appears strongly punctate, a character which distinguishes this form from *C. Siluriana*.

CRANIA SPINIGERA, *Hall.*

Plate 27, *Fig.* 1.

Crania spinigera, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 13. 1879.

Shell very broadly oval, wider than long, slightly concave on the margin near the apex. Upper valve depressed subconical, apex transversely subcentral, distant from the concave margin about one-third of the longitudinal diameter. Lower or ventral valve not observed.

Surface marked by very fine, sharp, lamellose, concentric striæ. Entire surface minutely papillose. Shell ornamented with irregular, interrupted radiating lines or ridges of small, short, tubular spines, diverging from the apex to the margins, and increasing in number by implantation only. These radiating lines are composed of a single row of imbricating spines forming a nearly continuous nodose ridge. The specimen described has over thirty of these rows at the margin.

When in a perfect condition the spines do not show their tubular character, being closed at the extremities. The individual is attached to the dorsal valve of *Rhynchonella Stricklandi*, and exhibits the plications of that shell continued over the CRANIA in corresponding folds, irrespective of the surface ornaments.

From *C. setifera* and *C. Siluriana*, with which it is associated, and from any other palæozoic form known, this species is distinguished by the radiating rows of spines.

LINGULA, *Bruguiere.*

Lingula gibbosa, *Hall.*

Plate 27, *Fig.* 2.

Lingula gibbosa, Hall. Trans. Alb. Inst., vol. x. Abstract, p. 13. 1879.

General form subelliptical, lateral margins curving, rounded at the base, and somewhat abruptly contracting towards the beak; valves gibbous on the umbones; greatest convexity at about one-third the length from the apex. Surface marked by fine irregular concentric striæ, which in some parts become lamellose, and also by concentric undulations.

PHOLIDOPS, *Hall.*

Pholidops ovalis, *Hall.*

Plate 21, *Figs.* 1, 2.

Pholidops ovalis, Hall. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.

P. ovalis, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 149, pl. 21, figs. 1, 2. 1879.

Shell round-oval, somewhat broader anterior to the middle; valves equally convex; apex situated about one-third the length of the shell from the posterior end. Surface marked by concentric lines of growth, which are strongly lamellose toward the margin.

This species differs from *P.* (*Orbicula*) *squamiformis* of the Niagara group of New York, in the greater convexity, more closely arranged concentric lines of growth, and in being more regularly and broadly oval. Rare.

ORTHIS, *Dalman.*

Orthis hybrida, *Sowerby.*

Plate 21, *Figs.* 18–25.

Orthis hybrida, (Sow.) Murch. Sil. Syst., p. 630, pl. 13, fig. 11. 1839.

Orthis hybrida, (Sow.) Hall. Pal. N. Y., vol. ii, p. 253, pl. 52, figs. 4*a*–4*o*. 1852.

Orthis hybrida? (Sow.) HALL. Trans. Alb. Inst., vol. iv, p. 209. Abstract p. 15; May, 1863.

Orthis hybrida, (Sow.) HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 149, pl. 21, figs. 18-25. 1879.

General form lenticular, or depressed spheroidal, wider than long; valves nearly equal, the ventral one depressed from the center to the base, while the dorsal valve is regularly convex, sometimes with a slight depression in the center near the beak; beaks almost equally elevated, the ventral one being scarcely incurved; hinge-line much shorter than the width of the shell; surface marked by thin sharp dichotomous striæ, which are arched upwards upon the sides and hinge-margin. Surface marked by radiating striæ crossed by extremely fine concentric striæ.

This species is readily distinguished by the near equality of the valves, one of which has a broad undefined depression along the center. The surface characters are very similar to *O. elegantula*, but the form of the shell, or of the separated valves, is quite sufficient to distinguish it.

This species is very common in the Waldron locality. The numerous specimens examined can be easily separated into two distinct varieties, one of them narrow and ventricose, with the anterior margins thickened and strongly lamellose, presenting strong varices of growth; another, broader and less ventricose, with sometimes a wide sinuosity in front. Few of the specimens have the broad sinuosity of the ventral valve and ventricose upper portion of the shell, so characteristic of the New York species which has been referred to *O. hybrida.*

ORTHIS ELEGANTULA, *Dalman.*

Plate 21, *Figs.* 11-17.

For *Synonymy*, see Pal. N. Y., vol. ii, p. 252. 1852.

Shell semi-oval; dorsal valve nearly or quite flat, sometimes with a depression along the centre; ventral valve very convex, extremely elevated towards the beak, which is much extended and incurved over the area; hinge-line shorter than the width of the shell; area narrow not extending to the extremities of the hinge-line. Surface ornamented with fine radiating striæ, which are dichotomous towards the margin and arched towards the hinge-line. In the better preserved specimens, the diverging striæ are crossed by very fine concentric striæ.

This species is closely allied to *O. testudinaria*, and perhaps more nearly to *O. parva*, both of which are lower Silurian species. In the present form, however, the shell is usually more elongated and the beak more extended, while the surface is marked by finer striæ, so that there is usually little difficulty in distinguishing it.

Compared with the New York representatives, this species, as found at Waldron, is much longer, wider in front, and the beak of the ventral valve not so pointed.

ORTHIS SUBNODOSA, *Hall.*

Plate 27, *Fig.* 17

Orthis subnodosa, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 14. 1879.

Ventral valve suborbicular, length and width about as 10 to 11; hinge-line much shorter than the width of the shell; an undefined mesial depression on the lower half of the shell; umbo prominent, beak small and slightly incurved; area small, triangular, apparently not occupying more than half the width of the valve; foramen large, reaching to the beak, wider than high.

Surface marked by subangular plications of which there are three in the mesial depression, the central one being interstitial, coming in below the umbo. There are about ten plications on each side of the mesial depression, some of these coming from bifurcation or interstitial additions; the plications are crossed by lamellose lines of growth, which give them a subnodose aspect.

This species resembles, in some of its features, the *O. fissicosta* of the Hudson river group.

ORTHIS BILOBA, *Linn.*

Plate 27, *Fig.* 16.

For citations, see Pal. N. Y., vol. ii, p. 260. 1852.

Shell bilobate, obcordate, sinuate in front; extremities of the cardinal linle auriculate; ventral valve very convex, arcuate; dorsal valve flat or slightly concave (rarely a little convex); area comparatively large, triangular, with a distinct triangular foramen. Surface striated; striæ dichotomous or in fascicles, radiating from the apex to each lobe of the shell; concentrically marked by fine striæ, which are deeply arched or sinuate in the sinus of each valve. The hinge of the dorsal valve is furnished with two simple teeth on its inner margin.

This peculiar little species is readily distinguished from any other known, except a closely allied form in the Shaly limestone of the Lower Helderberg group in New York, known as *Orthis varica*. This latter species, however, attains a larger size than that of the Niagara group; the cardinal area is proportionally smaller, and the hinge-line is less extended; likewise the dorsal valve is always more or less convex, particularly in the upper part, while in very rare instances the Niagara species has the dorsal valve a little convex, with the ventral valve more arcuate, and the surface marked by fewer striæ.

Individuals of *O. varica* are extremely abundant at a locality of the Lower Helderberg group in the State of New York, while, so far as known, *O. biloba* has not been found in any considerable numbers at any locality. It is a very rare form in the shales at Waldron, and the specimens are somewhat smaller and more delicate than is usual.

STREPTORHYNCHUS, *King*.

STREPTORHYNCHUS TENUIS, *Hall*.

Plate 23, *Figs*. 11–13.

Streptorhynchus tenuis, HALL. Trans. Alb. Inst., vol. iv, p. 210. Abstract, p. 16; May, 1863.

S. tenuis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 150, pl. 23, figs. 11-13, 1879.

Shell large, semi-circular or broadly semi-elliptical, cardinal line less than the greatest width of the shell, cardinal extremities rounded. Ventral valve slightly concave; area narrow; beak slightly elevated. Dorsal valve moderately convex, umbo not prominent, arcuate near the front margin, and compressed near the cardinal extremities.

Surface marked by moderately fine, rounded, alternately large and small thread-like striæ, which are strongly curved on the lateral portions of the shell, crossed by a very fine concentric striæ, giving under a lens, a beautiful rugose character. Substance of shell very thin.

Length of one specimen, forty millimeters, with a breadth of 50 mm.

This species differs from any other of the genus known in rocks of this age, in the rugose surface and rounded cardinal extremities; in this respect it has more the character of the carboniferous forms of Streptorhynchus. But few individuals of the species have been observed in the extensive collections made at the locality.

STREPTORHYNCHUS SUBPLANA, *Conrad.*

Plate 21, *Figs.* 26–33.

Strophomena subplana, CONRAD. Journ. Acad. Nat. Soc. Phil., vol. viii, p. 258. 1842.

Leptæna subplana, (CONR.) HALL. Pal. N. Y., vol. ii, p. 259, pl. 53, figs. 8-10. 1852.

Streptorhynchus subplana, (CONR.) HALL. Trans. Alb. Inst., vol. iv, p. 226. Abstract, p. 32; May, 1863. 16th Rep. State Cab. Nat. Hist., p. 63. Geol. Rep. Wis., 1862, p. 436. 28th Rep. N. Y. St. Mus. Nat. Hist., p. 151, pl. 21, figs. 26–33. 1879.

Shell resupinate, semi-elliptical, length and width often equal; hinge-line extending beyond the width of the shell. Surface marked by prominent sharp striæ, which frequently bifurcate before reaching the margin; radiating striæ crossed by strong concentric striæ. Cardinal area extending to the extremities of the hinge-line, narrow, partially formed by both valves.

This species occurs somewhat abundantly, and differs but slightly from the New York form. It is proportionally wider and shows less of the tendency to become mucronate at the cardinal angles.

STROPHOMENA, *Raf.*

STROPHOMENA RHOMBOIDALIS, *Wilckens.*

Plate 22, *Figs.* 4-10.

Conchites rhomboidalis, WILCKENS. Nachricht von seltener Verst, p. 77, pl. viii, figs. 43, 44. 1769.

For *Synonymy*, see Pal. N. Y., vol. iii, p. 195, under *Strophomena rugosa*; and ibid. vol. iv, p. 76.

Shell varying from semi-elliptical to semi-circular. Hinge-line equaling or greater than the width of the shell below; cardinal extremities often much extended. Dorsal valve flat or slightly concave in the upper part, and abruptly curving or inflated towards the front; beak prominent, perforate at its apex, and filling a deep sinus in the opposite valve. Ventral valve slightly convex or nearly flat in its upper part, and sometimes even concave; convex upon the umbo, often perforate near the beak; abruptly deflected or geniculate towards the front; cardinal area narrow, linear, partially occupying both valves. Foramen of the ventral valve a broad, shallow sinus, which is filled by the prominent process of the opposite valve, the latter being perforate or deeply grooved for the passage of a pedicle.

Surface marked by regular, rounded, radiating striæ, which increase by bifurcation and interstitial addition. The upper part of the valves is ornamented with strong concentric wrinkles which do not extend below the abrupt bending of the valves.

The interior of the shell is striato-punctate, or sometimes simply punctate. The muscular areas of the ventral valve are strong, more or less deeply bilobed, and limited by the extension of the dental lamellæ. The interior of the dorsal valve is strongly marked by the muscular impressions; the dental process is perforated near its outer surface, or deeply grooved; and there is often a deep cavity below this, extending towards the beak.

This shell exhibits much variety of form, being sometimes nearly flat or but slightly curved near the margin; and the corrugations are variable in number and strength. In very old shells they are often not as prominent as in younger ones, or those of medium size. The area, as usually exposed, is subject to much variation, and not unfrequently the valves are so closed as to leave no visable area.

This variable species is very abundant, and occurs of somewhat larger size than those figured. Specimens having a width of fifty millimeters are not uncommon.

STROPHODONTA, *Hall.*

STROPHODONTA PROFUNDA, *Hall.*

Plate 23, *Figs.* 9, 10; *Plate* 27, *Fig.* 18.

Leptæna profunda, HALL. Pal. N. Y., vol. ii, p. 61, pl. 21, figs. 4, 5. 1852.

Strophodonta profunda, HALL. 20th Rep. St. Cab. Nat. Hist., p. 369, pl. 13, figs. 3, 4. 1867. Rev. edit., p. 376, pl. 13, figs. 3, 4. [1870.]

Strophodonta profunda, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 151, pl. 23, figs. 9, 10. 1879.

Shell large, broadly semi-oval, the full grown individuals having a width of about sixty millimeters, with a length of about 40 mm.; greatest width along the hinge-line: deeply concavo-convex, point of greatest convexity in front of the middle. Cardinal angles slightly extended and subauriculate, in the casts often obtuse or rounded.

Ventral valve very convex, beak slightly elevated, cardinal margin sloping and a little concave to the cardinal angles, moderately convex for more than half the length, and rapidly dscending to the margin. Hinge area narrow; foramen triangular, width about equal to the height; covered by a strong deltidial callosity. The crenulations or teeth on the interior margin are oblique, diverging from the beak, extending from the foramen less than half way to the cardinal angles. Muscular impression subtriangular or flabelliform, extending for two-fifths the length of the shell. A central longitudinal callosity extends from the apex, sometimes for one-third of the length of the muscular impression.

Dorsal valve very concave, nearly following the contour of the ventral valve. Hinge area narrower than that of the ventral valve; foramen covered by a callosity.

Surface marked by strong, large, radiating striæ, alternating with four or five smaller striæ and increasing by implantation; radiating striæ crossed by very fine, sharp, crowded, regular, continuous, crenulating concentric striæ; the smaller radiating striæ often become stronger, forming the larger and less regular striæ; interior of valves papillose or punctate.

The surface of many of the older specimens is more irregularly fasciculate, and the stronger striæ rise in unequal ridges. This latter feature is, in a greater or less degree, impressed upon the casts of the interior, which, combined with strong vascular markings, gives a distinguishing character to specimens in that condition.

A fine large specimen in the collections from Waldron shows several specific characters not observed in the imperfect material from which the original description was drawn.

STROPHODONTA STRIATA, *Hall.*

Plate 23, *Figs.* 1-6.

Strophomena striata, HALL. Geol. of N. Y. Surv. 4th Geol. Dist., p. 104, fig. 3. 1843.

Leptæna striata, HALL. Pal. N. Y., vol. ii, p. 259, pl. 53, fig. 7. 1852.

Strophodonta striata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 152, pl. 23, figs. 1-6. 1879.

Shell semi-elliptical; hinge-line equal or a little longer than the width of the shell; dorsal valve slightly convex; ventral valve flat or somewhat concave. Surface concentrically finely striated, and also marked by fine lines of growth which are not always conspicuous.

This species is of common occurrence in the Waldron locality and the specimens are usually larger than those of the New York fauna. The figures given on plate 23, illustrate the interior structure which has not been observed in any of the specimens from the Niagara group of New York. In the ventral valve, the muscular area is limited by slightly curving dental lamellæ, and in well-preserved specimens there is a slender ridge along the center; the muscular impressions are not distinctly marked. The inner cardinal margins of the valves are marked by about fifteen slightly diverging crenulations on each side of the foramen, which occupy little more than one-third of the distance from the center to the extremities of the shell.

STROPHONELLA, *Hall.*

On several occasions, and notably in the *Sixteenth Report on the State Cabinet of Natural History*, and in vol. iv of the *Palæontology of New York*, the writer has indicated the existence of a small group of strophomenoid shells which are not strictly included in STROPHOMENA, STROPHODONTA or STREPTORHYNCHUS, though intimately related to these genera. The features are essentially those of STREPTORHYNCHUS in the resupinate position of the valves, and to a great extent in the muscular impressions; but the inner margins of the cardinal areas are crenulate, and the area usually solid with sometimes a triangular deltidium. These forms are separated from STROPHODONTA chiefly by their resupinate character, the strong and more restricted muscular impression of the ventral valve, which occupies a shorter and wider area, and by the muscular area and strong median septum in the dorsal valve. The cardinal process is similar to that of STROPHODONTA and also to some of the Devonian forms of STREPTORHYNCHUS. The characteristic features of these forms are as follows:

Shell semi-circular or semi-elliptical, concavo-convex, resupinate, the ventral valve concave and the dorsal valve convex. Ventral area striated, solid, with or without a central deltidial scar, or rarely a partial foramen, with similar features on the narrow area of the dorsal valve; inner margins of the cardinal areas of each valve crenulate, and from beneath the center of the ventral area there is often a strong process (frequently bilobed) which extends beyond the cardinal line. Muscular area of the ventral valve strongly marked, and limited by a prominent border. Dorsal valve with a narrow hinge area transversely or longitudinally striate or both, and marked in the center by a deltidial scar. Cardinal process double, each division notched or bidentate at the extremity; muscular area quadrangular, occupying a more or less elevated callosity, and a central carina rising from the lower part of this area is sometimes produced into a spiniform process in the center of the cavity.

The species at present known as possessing the characters of the genus are the following:

Strophonella semifasciata, Niagara group; *Strophonella Leavenworthana*, *S. cavumbona* and *S. punctulifera* (the two latter probably identical), Lower Helderberg group; *S. ampla*, Upper Helderberg group; *S. reversa*, Hamilton group, Iowa; *S. cœlata*, Chemung group.

STROPHONELLA SEMIFASCIATA, *Hall.*

Plate 22, *Figs.* 1–3; *Plate* 23, *Figs.* 7, 8.

Strophomena (*Strophodonta?*) *semifasciata*, HALL. Trans. Alb. Inst., vol. iv, p. 210. Abstract, p. 16. May, 1863.

Strophomena (*Strophodonta*) *semifasciata*, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of plates 22 and 23. 1876.

Strophonella semifasciata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.. Mus. ed., p. 154, pl. 22, figs. 1–3; pl. 23, figs. 7, 8. 1879.

Shell large, concavo-convex, resupinate, transversely semicircular, width nearly twice the length; cardinal extremities somewhat rounded. Ventral valve with slightly elevated umbo and small pointed beak; the middle of the shell deeply concave and abruptly inflected toward the front; area narrow, with a distinct triangular callosity. Dorsal valve depressed-convex from the umbo to near the middle, becoming subgeniculate in front; area about half as high as that of the ventral valve. Both areas distinctly striate, and marked by crenulations of the inner margin.

Surface of the upper and middle portions of the shell, marked by strong, irregular, distant, rounded, elevated striæ; near the front of the shell the striæ become more crowded by the intercalation of finer ones. Entire surface marked by fine concentric striæ. Interior surface of valves marked by closely arranged pustules. Substance of shell very thin.

This species has some resemblance to *Strophomena euglypha* (Dalman), but is much more extended on the hinge-line, the length and breadth being as two to three; while in that species the proportions are nearly as three to four. This shell has not the fine intermediate striæ, nor the punctate surface represented in that species. It is quite rare, but few specimens having been obtained in the entire collection.

CHONETES, *Fischer*.

CHONETES NOVA-SCOTICA, *Hall*.

Plate 22, *Figs*. 11-14.

Chonetes Nova-Scotica, HALL. Silurian and Devonian Rocks of Nova Scotia, by J. W. Dawson, p. 13. 1860.

Chonetes Nova-Scotica, HALL. Canadian Nat. and Geologist, vol. v, no. 2, p. 144. 1860.

Chonetes Nova-Scotica, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 155, pl. 22, figs. 11-14. 1879.

Shell semi-elliptical, width varying from once and a half to nearly twice the length, greatest width near the middle. Ventral valve variably convex, and often showing a flattened or slightly concave space down the middle of the shell, with occasionally a stronger and more elevated ray along the median line from beak to base of the ventral valve; cardinal margin ornamented by from two to five slender spines on each side of the beak; cardino-lateral margins often a little wrinkled. Dorsal valve moderately concave. Surface finely striated, striæ flexuous, dichotomizing and increasing by interstitial addition so that there are more than one hundred on the margin of the shell, stronger below the umbo; concentric striæ fine, close, rounded and slightly undulating.

This species resembles in form the *Chonetes cornuta* of the Clinton group of New York, but is a larger and more ventricose shell; the striæ are proportionally less numerous and more closely arranged, the interstices being less than the striæ, while in *C. cornuta* the interstices are wider than the striæ, and the latter increase only by interstitial additions below the middle of the shell.

All the specimens from Waldron belong to the variety with a strong median ray on the ventral valve. One specimen observed has a width of sixteen millimeters—considerably greater than the individuals figured.

Not common.

CHONETES UNDULATA, *Hall.*

Plate 22, *Fig.* 15.

Chonetes minima, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 22, fig. 15. 1876.

Chonetes undulata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 155, pl. 22, fig. 15. 1879.

Not *Chonetes minima*, SOWERBY. 1839.

Shell semi-circular length equal to six-tenths of the width, cardinal line straight, greater than the width of the shell below. Ventral valve regularly convex, the greatest convexity about the middle of the shell, somewhat abruptly curving to the anterior margin, cardinal angles very slightly flattened. Ventral area linear, extending to the hinge extremities; foramen equal in height to the ventral area and wider than high. Dorsal valve concave; area indicated only by the thickness of the shell.

Surface marked by obscure radiating plications which are broad and rounded below, and obsolescent toward the beak; cardinal margin of the ventral valve ornamented by two diverging spines on each side of the beak.

This species is especially characterized by the rounded plications, which are frequently obscure and often obsolescent on the center of the valve, where they appear as simple undulations of the surface. The bases of two spines on each side of the beak are usually preserved, and no specimen examined has shown more than that number.

SPIRIFERA, *Sowerby.*

SPIRIFERA EUDORA, *Hall.*

Plate 24, *Figs.* 13-18.

Spirifer Eudora, HALL. An. Geol. Rep. of Wis. 1861.

Spirifer Eudora, HALL. Trans. Alb. Inst., vol. iv, p. 211, Abstract p. 17; May, 1863.

Spirifera Eudora, HALL. 20th Rep. State Cab. Nat. Hist., p. 370, pl. 13, figs. 5, 7. 1867. Rev. edit., p. 377, pl. 13, figs. 5, 7. [1870.]

Spirifera Eudora, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 156, pl. 24, figs. 13, 18. 1879.

Compare *S. Niagarensis*, var. *oligoptycha*, F. ROEMER. Sil. Faun. Westl. Tenn., p, 68, pl. 5, fig. 8.

Shell of moderate size, transversely subovate, length and width as three to four, valves extremely gibbous; hinge-line less than the width of the shell below; cardinal extremities rounded; area moderately high; foramen triangular, a little higher than wide; surface marked by three to four simple, strong angular plications on each side of the mesial fold and sinus. Dorsal valve regularly arcuate; beak somewhat incurved; mesial fold of moderate width, flattened above and slightly depressed in the lower part. Ventral valve most prominent near the umbo; beak strongly incurved over the area; mesial sinus broad and deep.

The minute surface markings, as shown in specimens from Waldron, are fine radiating striæ, precisely like those of *S. macropleura* of the lower Helderberg group of New York. This species was originally described from casts from the limestone of Racine, Wisconsin. The casts show a higher area than the entire specimens, since the strongly incurved beak of the ventral valve covers much of the area, giving a less distance between the beaks of the opposite valves than is shown in the casts.

The species given by Roemer as *S. Niagarensis* var. *oligoptycha* differs from this species in the proportionally longer hinge-line; and when compared with specimens of *S. macropleura* from Tennessee, presents no essential differences of character.

SPIRIFERA CRISPA, *Hisinger*.

Plate 24, *Figs.* 6-12 *and* 19.

For *Synonymy*, see Pal. N. Y. vol. ii, p. 262. 1852.

Shell subrhomboidal, gibbous; dorsal valve semi-circular; valves very unequal, the ventral one extremely convex, with the beak extended and incurved. Surface marked by five or six, rarely eight, plications on each valve. These are sometimes obsolete. Concentrically marked by fine elevated thread-like striæ. Cardinal area broad, extremities short; foramen long, narrow.

This species occurs in considerable numbers in the Waldron collections, presenting the same variety of form and proportions that we find in this species in New York and elsewhere. Many of the specimens, however, are larger and more rotund than the latter.

There seems to be no sufficient reason for separating this form from *S. crispa* of Europe.

SPIRIFERA CRISPA, var. SIMPLEX, *Hall.*

Plate 24, *Figs.* 1-5.

Spirifer crispus, var. HALL. Trans. Alb. Inst., vol. iv, p. 212. Abstract p. 18; May 1863.

Spirifera crispa, var. *simplex*, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 157, pl. 24, figs. 1-5; 1879.

There are numerous small symmetrical specimens which have almost uniformly a single plication on each side of the mesial fold, presenting three folds of nearly equal size. The ventral valve has two folds on each side of the mesial sinus, and the valves are almost equally convex. The surface is marked as in the larger specimens.

SPIRIFERA RADIATA, *Sowerby.*

Plate 24, *Figs.* 20-30.

For *Synonymy*, see 20th Rep. State Cab. Nat. Hist., p. 371. 1867.

Shell variable in form, subtriangular, rotund or subglobose. Valves almost equally convex, the beak of the ventral valve more or less extended, and curving over the dorsal valve. Hinge-line often less than the width of the shell, the extremities being rounded. Surface marked by fine, close, radiating striæ. Ventral area more or less exposed, giving a very variable appearance to the shell. Foramen long and narrow, often partially or entirely closed by a deltidium. Interior plates of the ventral valve near together, and extending downwards within the limits of the mesial depression.

Large and fine specimens of this species are found in considerable abundance. The individuals are larger and in a much finer state of preservation than those found in the Niagara shales of New York. The form is more rotund, the cardinal extremities more distinctly rounded, the ventral area of moderate height and distinctly striated longitudinally, and the foramen is often partially covered by a deltidium. The aspect of the interior of a well-preserved specimen of the ventral valve, as it occurs at Waldron, is well represented by fig. 25, of plate viii, in Mr. Davidson's *Introduction to the Study of the Brachiopoda.*

This form is regarded by Mr. Davidson and other authors, as a variety of *S. plicatella* of Linneus, but there has never been seen, among our American specimens, any individual showing plications like the English and continental European specimens. The Waldron specimens have usually the form of those illustrated by Mr. Davidson as *S. plicatella* var. *globosa*. This author says, in regard to the surface of the *S. plicatella* var. *radiata*, that "the external sculpture, when well preserved, is extremely beautiful, and consists of radiating ribs (five in the width of a line in the middle of an average sized specimen), not always quite regular in their respective widths, but usually leaving an interspace between each two of about the width of one of the ribs, and at times toward the margin, there are smaller ribs interpolated; these ribs are regularly crossed by equidistant, concentric, projecting ridges, which give to the shell surface a beautifully imbricated appearance." This description of the character of surface of the English specimens is scarcely applicable to the American specimens which we refer to *S. radiata*. In the Waldron specimens, the radii are finer than above described, there being eight or more in the width of a line, while the interspaces are not more than half as wide as the radii. The radii are also distinctly flattened and are increased by bifurcation or dichotomizing, and rarely by intercalation of smaller striæ. These characters are illustrated in figure 30 of plate 24. The concentric striæ are obscurely visible or obsolete. Of the *Spirifera plicatella* var. *globosa*, Mr. Davidson says: "It is easily connected with *Spirifera radiata* of Sowerby. Indeed, there appears to be little by which it can be distinguished from the true *Spirifera radiata*, except the greater convexity or gibbosity of its valves and its finer striation."

The *Spirifera Niagarensis*, which has a similar form and surface markings is distinctly plicate, but it is not known to present the elevated area, incurved beak, and gibbous form, which is represented in the European specimens of *S. plicatella*. In the Niagara shales in the State of New York the *S. Niagarensis* is abundant, while *S. radiata* is comparatively rare. At Waldron *S. radiata* has acquired a remarkable development in numbers and in the size of the specimens, but we have not observed a single specimen of *S. Niagarensis* in all the collections made at that locality.

SPIRIFERA BICOSTATA? var. PETILA, *Hall*.

Plate 27, *Figs*. 8, 9.

Spirifera bicostata? var. *petila*, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 15. 1879.

Shell obliquely subpyramidal, wider than long; hinge-line straight, about four-fifths the greatest width of the shell, rounded at the extremities. Ventral valve gibbous, subpyramidal; beak incurved, umbo prominent, abruptly curving to the basal and basolateral margins; sinus visible at the apex and becoming wider and deeper towards the front, margined on each side by a strong plication, and between this and the cardinal extremity on each side are one or more obscure folds. Area elevated, triangular, margins rounded; foramen higher than wide, with elevated margins, and occupying one-third of the area. Dorsal valve moderately convex, the greatest convexity just above the middle; mesial fold indistinct above, becoming prominent towards the base, marked on each side by one or two obscure undulations. Surface marked by concentric undulating ridges, and intermediate fine radiating striæ.

This form resembles *Sp. bicostata* of the Niagara limestone of New York, but is much smaller and with the ventral valve more elevated.

TRIPLESIA, *Hall.*

TRIPLESIA PUTILLUS, *Hall.*

Plate 27, *Figs.* 19–22.

Triplesia putillus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 16. 1879.
Compare *Spirifera? Waldronensis*, MILLER & DYER. Contributions to Palæontology, Journal of the Cincinnati Society of Natural History, April, 1878.

Shell small, subquadrate in outline, length and breadth nearly equal, hinge-line straight, less than the width of the shell, extremities rounded. Ventral valve slightly convex on each side of the sinus, becoming concave near the margins; mesial sinus undefined above, becoming wide and deep below, and produced in front into a long triangular extension; beak greatly elevated, acute, extending beyond the hinge-line, the apex obscurely marked by what appears to be a minute foramen; area triangular, wider than high; deltidium triangular, higher than wide. Dorsal valve very gibbous; moderately convex on each side of the fold, and slightly concave just within the margins; mesial fold commencing about one-third the length of the valve below the beak and becoming very prominent toward the base; summit of the fold straight, its greatest elevation being at the basal margin; beak obtuse, closely incurved.

Surface marked by fine concentric lines of growth, which, *toward the margins,* become strong lamellose striæ.

The specimens of this species are distorted in their mode of growth, apparently from the natural obliquity of the mesial fold and sinus.

PENTAMERUS, *Sowerby*.

PENTAMERUS FORNICATUS, var. *Hall*.

Plate 27, *Fig*. 15.

Pentamerus fornicatus, var. HALL. Trans. Alb. Inst., vol. x. Abstract, p. 16. 1879.
Pentamerus fornicatus, HALL. Pal. N. Y., vol. ii, p. 81, pl. 24, fig. 7.

Shell ventricose, larger valve highly arcuate, length less than the width, umbo gibbous, beak strongly incurved; a broad shallow and undefined mesial sinus extends from the umbo to the base of the shell, having in the center a low, distinct elevation which gives a double sinus: the median elevation is scarcely so high as the shell on each side, prolonged in front, and terminating in a distinct emargination for the reception of the median extension of the opposite valve.

Surface marked by fine sublamellose striæ of growth, which are distinctly curved backwards on the prominent parts of the shell and forward in the depressions.

This form so nearly resembles *Pentamerus fornicatus* of the Clinton limestone, that it can only be regarded as a variety of that species.

MERISTELLA, *Hall*.

Subgenus MERISTINA, *Hall*.

MERISTINA MARIA, *Hall*.

Plate 25, *Figs*. 8-12.

Meristella Maria, HALL. Trans. Alb. Inst., vol. iv, p. 212. Abstract p. 18; May, 1863.
Meristina Maria, HALL. Pal. N. Y., vol. iv, p. 299. 1867.
Meristina Maria, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 159, pl. 25, figs. 8-12. 1879.

Shell of medium or large size, ventricose, broadly ovate or subquadrangular. Ventral valve gibbous above, with a subangular ridge extending from the beak to near the middle, where it becomes flattened, sinuate and bent abruptly upward in a prolonged linguiform extension; beak obtuse, closely incurved over the opposite valve; cardinal slopes angular and the cardinal border inflected. Dorsal valve gibbous, strongly arcuate transversely, prominently subangular along the middle, and in the lower part presenting a broad, undefined fold, deeply emarginate in front for the reception of the extension of the opposite valve; beak obtuse, strongly incurved.

Surface marked by strong concentric lines of growth. Interior of ventral valve marked by two strong diverging dental lamellæ which extend to near the middle, limiting a deep triangular muscular cavity.

This species is most nearly related to *Meristella* (*Merista*) *tumida* of European authors, but is less rotund, while that species does not possess the peculiar flattening of the cardinal half of the ventral valve and its accompanying subangular ridge. It differs from all the other species of the Niagara and lower Helderberg groups, but approaches in some characters to the *Meristella* (*Atrypa*) *crassirostra* of the Niagara group (Pal. N. Y. vol. ii). The *M. nitida* occurs with this species, and is readily distinguished from it by its emarginate front, and the absence of an elevated fold on the dorsal valve.

Very abundant at the Waldron locality.

MERISTINA NITIDA, *Hall.*

Plate 25, *Figs.* 1-7.

Atrypa nitida, HALL. Geol. of N. Y. Geol. Surv. 4th Dist. Tab. of Organic Remains, p. 11, no. 14 (no. 13 on plate), fig. 5. 1848.

Atrypa nitida, HALL. Pal. N. Y., vol. ii, p. 268, pl. 55, figs. 1*a*-1*o*. 1852.

Merista nitida, HALL. 12th Rep. St. Cab. Nat. Hist., p. 78. 1859.

Meristella nitida, HALL. Trans. Alb. Inst., vol. iv, p. 226. Abstract p. 32; May, 1863.

Meristina nitida, HALL. Pal. N. Y., vol. iv, p. 299. 1867.

Meristina nitida, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 160, pl. 25, figs. 1-7. 1879.

Shell ovoid, with the beaks more or less extended. Valves nearly equally convex, the beak of the ventral valve being much elevated above, and incurving over the dorsal valve. The ventral valve is sometimes marked near the base, by a longitudinal depression, often forming an emargination in front. Surface smooth, or with fine concentric striæ and a few conspicuous lines of growth towards the base, which are also sometimes found as far back as the middle of the shell.

This species is very abundant and variable in character, and much larger than the New York specimens of this shell. The form varies from narrow ovate and very ventricose to broadly rhomboid ovate and strongly emarginate in front.

MERISTELLA, *Hall.*

MERISTELLA RECTIROSTRA, *Hall.*

Plate 27, *Figs.* 10–14.

Meristella rectirostra, HALL. Trans. Alb. Inst. vol. x. Abstract, p. 15. 1879.

Shell broadly ovate, acute at the beak, thence rapidly expanding; the dorso-lateral margins nearly straight for one-third the length of the shell, and then broadly curving, giving the body of the shell (in older individuals) a depressed orbicular or sublentiform aspect; younger shells ovate or acute. Valves almost equally convex. Ventral valve most convex a little above the middle, thence curving to the lateral and basal margins; sinus none,.or very obscure; beak elevated, acute, attenuate, nearly straight or very slightly arcuate; area and foramen triangular without deltidial plates. Dorsal valve very convex above the middle, sloping abruptly to the lateral, and more gently to the anterior margin; beak closely incurved into the triangular foramen of the ventral valve.

Surface usually appearing smooth, but is marked by extremely fine radiating striæ, which give a cancellated appearance under a lens. The larger specimens measure eleven millimeters in length by about 9 mm. in width.

This species is very distinct from the two other forms of the genus from this locality, both in its proportions and general aspect; but more especially in the nearly straight beak and open triangular foramen. The specimens have the aspect of CRYPTONELLA, but are clearly shown to possess spires arranged as in MERISTELLA.

NUCLEOSPIRA, *Hall.*

NUCLEOSPIRA PISIFORMIS, *Hall.*

Plate 25, *Figs*, 22-28.

Orthis pisum, (MURCH.) HALL. Pal. N. Y., vol. ii, p. 250, pl. 52, figs. 1*a*-1*e*. 1852.
Nucleospira pisiformis, HALL. Pal. N. Y. vol. iii, Expl. pl. 28 B. 1859.

Nucleospira pisiformis, HALL. Trans. Alb. Inst., vol. iv, p. 226. Abstract, p. 32; May, 1863.

Nucleospira pisiformis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 160, pl. 25, figs. 22-28. 1879.

Shell lenticular, globulose; valves nearly equal, each valve with a slight depression down the centre. Ventral valve somewhat more convex, and the beak more elevated than in the dorsal valve. Area narrow, small, scarcely extending beyond the width of the beaks at their base. Surface marked by fine concentric striæ, usually obscured by the covering of minute, hair-like spines, which, when removed, leave a punctate surface.

This species is common. Many of the specimens are almost entirely covered with long fine setæ projecting beyond the margins, forming a marginal fringe.

RETZIA, *King*.

RETZIA EVAX, *Hall*.

Plate 25, Figs 13-21.

Rhynchospira evax, HALL. Trans. Alb. Inst., vol. iv, p. 213. Abstract p. 19; May, 1863.

Retzia evax, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 25, figs. 13-21. 1876. Mus. edit., p. 160. 1879.

Shell ovate, often broadly ovate, usually longer than wide, sometimes much longer; both valves gibbous in the middle and upper part, ventral valve a little deeper than the opposite, both valves sometimes marked by a shallow undefined sinus, causing an emargination in front. Ventral beak much elevated above the other, and incurved, so as to bring the plane of the foramen parallel to the axis of the shell; foramen distinctly rounded, with a visible triangular space below, which is occupied by two small deltidial plates. Dorsal valve regularly arcuate except near the front; beak closely incurved beneath the deltidial plates of the opposite valve. In some old specimens there is a broad undefined mesial elevation on the lower part of the valve including about five or six plications besides the central one, which is divided into two or three smaller ones (a generic feature). Sometimes there is a broad, undefined depression and frequently only a narrow depression caused by the subdivided central plication. The ventral valve has uniformly a longitudinal sinus, which includes two or three small plications arising from the subdivision of the central one, and sometimes including one or two on each side.

This shell is marked by radiating, rounded or subangular costæ or plications, from eight to fourteen on each side of the central one; those on the cardinal slopes sometimes bifurcating or with interstitial additions, while in a few individuals bifurcating costæ occur on other parts of the valve; the interspaces are rounded grooves of about the same size as the plications. The surface is marked by fine concentric striæ and stronger, imbricating lamellose lines of growth.

This species differs from *R.* (*Atrypa*) *aprinis* of the Niagara group of New York, in being more ovate in form and less gibbous toward the front, while the ventral beak is more elevated. It approaches very nearly in character to the *R. formosa* of the Lower Helderberg group, and the shell is subject to similar variations of form, proportions and incurvation of the beak, which in some specimens of both species is closed upon the opposite beak. The central plication in both species is divided into two or three, and the dorsal valve likewise presents sometimes a mesial elevation and sometimes a depression.

The largest individual measured has a length of more than twenty-five millimeters, with a width nearly as great. The specimens vary from 2 mm. to about 25 mm. in length.

This species is comparatively numerous.

CŒLOSPIRA, *Hall.*

CŒLOSPIRA DISPARILIS, *Hall.*

Plate 25, *Figs.* 39-43.

Atrypa disparilis, HALL. Pal. N. Y., vol. ii, p. 277, pl. 57, figs. 6*a*-6*m*. 1852.
Leptocœlia disparilis, HALL. 10th Rep. St. Cab. Nat. Hist., p. 108. 1857.
Cœlospira disparilis, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 25, figs. 39-43. 1876. Mus. edit., p. 162. 1879.

Shell suboval, plano-convex. Ventral valve very convex, arcuate, with the beak extended and perforated at the apex, slightly curved over the dorsal valve, with two very prominent plications down the center, and two, three or four smaller ones on each side. Dorsal valve flat or slightly concave with a smaller plication down the depressed center, and two to four on each side. Plications crossed by fine, nearly obsolete concentric striæ and, a few stronger imbricating lamellæ of growth.

This peculiar little shell is easily recognized from the great disparity of the valves, the dorsal one being always quite plane or concave, while the ventral valve is very convex. The number of plications is variable, and there is sometimes a tendency to bifurcation or interplication among the lateral ones. There is in the Lower Helderburg group of New York, a species very similar to this one, but it is a larger and stronger shell. There is likewise in that rock, another species of similar form, but with finer plications.

This species is comparatively rare. The specimens from the Waldron locality show considerable variation in form, convexity of the valves, and number of plications. Compared with specimens of *Retzia Barrandii* (Davidson, 1848) from Dudley, England, they seem to be very closely related, if not identical.

ATRYPA, *Dalman.*

ATRYPA RETICULARIS, *Linn.*

Plate 25, *Figs.* 44–47.

For *Synonymy*, see Pal. N. Y., vol. iv, p. 316. 1867.

Shell depressed-globose, more or less circular in outline, slightly truncated by the hinge-line. Valves nearly equal in size; the ventral valve much more convex than the dorsal valve. Ventral valve often with an undefined depression or sinus at the base, and a corresponding elevation on the dorsal valve. Extremities of the cardinal line sometimes extended a little beyond the width of the shell. Beak of the ventral valve perforate, small and slightly elevated above the dorsal valve, or above the hinge-line. Surface marked by from twenty-four to thirty rounded plications, which bifurcate about one-third of the distance from the beak to the margin. Plications crossed by prominent imbricating concentric laminæ, which are often produced into short spines.

This is a very abundant species. Many of the specimens are more rugose than is usual in other localities.

ZYGOSPIRA, *Hall.*

ZYGOSPIRA MINIMA. *Hall.*

Plate 27, *Fig.* 7.

Zygospira minima, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 14. 1879.

A small subglobose form, about as long as wide. Ventral valve extremely gibbous, with a slight emargination in front. Dorsal valve gibbous on the umbo, depressed in the middle, and concave towards the front, presenting the feature of a broad, shallow, undefined sinus. Surface marked by strong radiating striæ.

The aspect of this fossil is characteristic of the genus ZYGOSPIRA, but the form is extremely gibbous and has the character of a mature shell, though its length is only two and a half millimeters.

RHYNCHONELLA, *Fischer.*

RHYNCHONELLA NEGLECTA, *Hall.*

Plate 26, *Figs.* 1-6; *Plate* 27, *Fig.* 3.

Atrypa neglecta, HALL. Pal. N. Y., vol. ii, p. 274, p. 57, figs. 1*a*-1*p*. 1852.
Rhynchonella neglecta, HALL. 12th Rep. St. Cab. Nat. Hist., p. 78. 1859.
Rhynchonella neglecta, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 162, pl. 26, figs. 1-6. 1879.

Shell ovoid or subpyramidal, gradually enlarging from the beaks to the base. In young individuals the base is rounded, but becomes deeply sinuate in older examples. Ventral valve with a mesial sinus below the middle and a corresponding fold upon the dorsal valve. Surface ornamented with simple sharp plications, which are crossed by fine concentric striæ, and sometimes by a few concentric imbricating lines of growth. In the young shells the valves are nearly equal, and there is neither sinus nor fold; but as the shell advances in size, the sinus becomes angular and conspicuous. There are generally three and sometimes four plications in the sinus, and four or five elevated on the opposite valve. The plications usually appear as if smooth, except near the base, where there are some strong imbricating lines of growth.

It is a common species at Waldron and may be distinguished from *R. Whitii* and *R. Indianensis* by its short form, and the fine sharp plications of the surface. Compared with specimens of the same species from the Niagara of New York, it is decidedly more angular in form, and with a deeper and more prolonged sinus.

RHYNCHONELLA ACINUS, *Hall.*

Plate 26, *Figs.* 7-11.

Rhynchonella acinus, HALL. Trans. Alb. Inst., vol. iv, p. 215. Abstract, p. 21; May, 1863.

Rhynchonella acinus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 163, pl. 26, figs. 7-11. 1879.

Shell small, longitudinally ovate, subattenuate toward the beak, and truncate in front, valves subequally convex. Ventral valve subarcuate, flattened in the middle, below which it is sinuate; beak incurved. Dorsal valve somewhat flattened in the middle, and sometimes a little depressed in the upper part of the median line, two of the plications becoming elevated towards the front, corresponding to an abruptly depressed sinus in the ventral valve, in the bottom of which is a single plication; three and rarely four plications on each side of the mesial fold of the dorsal valve, and four on each side of the sinus of the ventral valve. Concentric lines of growth usually but faintly marked.

Length from 5 to 10 millimeters; length and breadth usually about as four to three, and the depth about equal to the width, giving a subquadrate transverse section.

This species differs from the *R. bidentata* of Hisinger, in being larger, more robust and ventricose, and proportionally more elongate; the plications are more rounded, and the whole aspect less angular. It approaches in form the *R. bialveata* of the Lower Helderberg group, but it is more robust, and the plications are more rounded.

RHYNCHONELLA INDIANENSIS, *Hall.*

Plate 26, *Figs.* 12-22; *Plate* 27, *Figs.* 4-6.

Rhynchonella Indianensis, HALL. Trans. Alb. Inst., vol. iv, p. 215. Abstract, p. 21; May, 1863.

Rhynchonella Indianensis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 163, pl. 26, figs. 12-22. 1876.

Shell broadly ovate or subtriangular, length and width nearly equal, the width sometimes exceeding the length; cardinal slopes in the more gibbous specimens flattened. Ventral valve with the beak pointed and incurved, depressed-convex in the middle and gradually becoming depressed and sinuate in front, two or three of the plications included in the sinus. Dorsal valve a little the more gibbous, somewhat flattened forward of the umbo; three or four of the plications continuing direct, and forming a mesial elevation, the lateral ones arching downward to the margin. Shell marked by from nine to twelve strong, rounded or subangular plications, which sometimes become obsolete toward the beak. The concentric lines are very obscure. Length about thirteen millimeters.

This species resembles the *R. neglecta* of the Niagara group of New York; but it is larger and more robust, with stronger and more rounded plications; it is associated with a more finely plicated species which is referred to that one.

RHYNCHONELLA WHITII, *Hall.*

Plate 26, *Figs.* 23–33.

Rhynchonella Whitii, HALL. Trans. Alb. Inst., vol. iv, p. 216. Abstract, p. 22; May, 1863.

Rhynchonella Whitii, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p, 164, pl. 26, figs. 23--33. 1879.

Shell subcircular or transverse and broadly elliptical, usually not very gibbous. Ventral valve shallow, most prominent on the umbo, beak abruptly attenuate and pointed, slightly incurved, sides flattened, strongly sinuate in the middle and gently curving upward in front. Dorsal valve more gibbous; beak obtuse and incurved beneath the opposite, elevated in the middle, forming a distinct mesial fold, arching on the sides; from five to six strong plications on each side of the mesial fold and sinus, with usually a single plication in the sinus, and two on the mesial fold; rarely one of the plications on the fold is bifurcate. Interspaces wider than the plications. Surface marked by close concentric lines of growth.

This species bears some resemblance to *R.* (*Atrypa*) *dentata* (Pal. N. Y., vol. i, p. 148), but is less gibbous, the plications less strong, the mesial fold less elevated, and the sinus much narrower. It also is related to *R. borealis*, Schloth. (Davidson's British Fossil Brachiopoda, No. iii, Pt. vii, p. 174, Pl. xxi, figs. 14–23), and is distinguished by its smaller and rounded form, less prominent plications, and by its surface-markings.

RHYNCHONELLA STRICKLANDI, *Sowerby*.

Plate 26, *Figs*. 34–40.

Terebratula Stricklandi, J. de C. Sow. Sil. Syst., pl. 13, fig. 19. 1839.
Terebratula crispata, Id., pl. 12, fig. 11. 1839.
Terebratula Stricklandi (Dav). Bull. Soc. Geol. France, 2d Ser., vol. v, p. 329. 1848.
Hypothyris Stricklandi (D'Orbigny). Podrome, vol. i, p. 37. 1849.
Hypothyris Stricklandi (McCoy). Brit. Pal. Foss., p. 206. 1855.
Rhynchonella Stricklandi (Morris). Catalogue of British Fossils, p. 146. 1854.
Rhynchonella Stricklandi (Salter). Siluria, 2d edit.; pp. 250, 544, pl. 22, fig. 11. 1859.
Rhynchonella Stricklandi (Lindstrom). Of v. K. Vet. Akad. Forhandl., p. 366. 1860.
Rhynchonella Tennesseensis (Rœmer). Hall. Trans. Alb. Inst., vol. iv, p. 228. Abstract, p. 34; May, 1863. Hall. Doc. edit. 28th Rep. St. Mus. Nat. Hist., pl. 26, figs. 34–40. 1876.
Rhynchonella Stricklandi? (Sow.) Hall. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 165, pl. 26, figs. 34–40. 1876.
Compare *Rhynchonella Tennesseensis* Rœmer. Sil. Faun. Westl. Tenn., p. 72, pl. 5, fig. 14. 1860.

Shell large, ovate, subtrigonal, very convex, sometimes wider than long, sides and front rounded. Dorsal valve very gibbous or ventricose, slightly flattened at the umbo; mesial fold wide, becoming very prominent as it approaches the front. Ventral valve less convex than the dorsal, beak small, closely incurved over the umbo of the opposite valve; sinus wide, flat, deep in front.

Surface of each valve ornamented with from twenty-five to thirty-four simple, angular, radiating ribs, of which six or eight occupy the fold and sinus.

The individuals belonging to this species were originally identified with *R. Tennesseensis* Roemer, a species described from the middle Silurian of Tennessee. The specimens from Waldron, in their prevailing forms, are much larger than the figures of Dr. Roemer, and the plications less angular than represented. The species now under consideration occurs in Tennessee, but is always smaller, and in that respect corresponds with the figures cited above. There is, however, another form, occurring with those of the Tennessee locality, which is shorter and comparatively broader, with more angular plications and abrupt thread-like transverse striæ, a more abrupt sinus and more acute beak. This form corresponds with the figures of Dr. Roemer, but it is quite unlike the specimens from Waldron.

A comparison of the Waldron specimens, and of the similar Tennessee form, with the figures of Mr. Davidson in his monograph of the Fossil Brachiopoda of Great Britain, indicates the specific identity of the specimens from these three localities. The Waldron specimens differ from those of Dudley, England, in being less gibbous, proportionally longer, the beak slightly more extended, the ventral valve nearly flat in a transverse direction across the upper half of the shell, the plications larger and more rounded, the sinus wider and less abrupt. The same differences are observed in comparison with the original figures of Sowerby (cited above) in the "*Silurian System.*" In both the works cited, however, the figures agree much more nearly with the Waldron specimens than those of Dr. Roemer.

RHYNCHOTRETA, *Hall.*

Type, *Rhynchonella cuneata*, DALMAN.

Shell triangular, surface with angular plications. Ventral beak straight, produced beyond the dorsal beak, extremity perforate, the foramen with an elevated margin; space between the foramen and hinge-line occupied by a deltidium in two pieces, being divided by a longitudinal suture, and transversely striated. Valves articulated by two slender curving teeth, proceeding from a broad curving hinge-plate in the ventral valve, which fit into corresponding sockets in the dorsal valve. Cruræ rising from near the dorsal beak, and curving into the ventral cavity, and thence recurved towards the dorsal side, and probably uniting, as shown in figure 4, p. 310. Structure fibrous and apparently very minutely punctate.

The *Rhynchonella cuneata* of Dalman has been retained under that genus by nearly all authors. In 1859, Salter referred the species to RETZIA. An examination of specimens in 1863 for the 4th vol. Pal. N. Y., revealed no satisfactory evidence of punctate structure, or internal cruræ or spires; and it was still continued under RHYNCHONELLA. The collections from Waldron have shown the punctate texture of the shell, and the existence of long curving cruræ, which are unlike any feature known in palæozoic RHYNCHONELLA, and assimilate this fossil to the Terebratulidæ.

This form is not congeneric with *Retzia Adrieni*, and can not properly be referred to that genus, though approaching in external characters to *R. ferita*, which is represented as possessing internal spires. It becomes necessary, therefore, to characterize it as a distinct genus, for which is proposed the name Rhynchotreta. The accompanying figures illustrate its principal features.

Fig. 1.

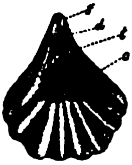


Fig. 2.

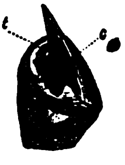


Fig. 3.

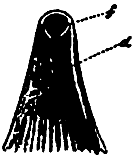


Fig. 4.

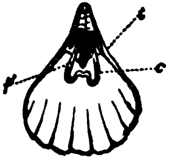


Fig. 1. Dorsal view, showing extent and divergence of the crural processes *c*, and one of the articulations of the ventral valve *t*.

Fig. 2. Lateral view, showing curvature and direction of crural processes.

Fig. 3. Enlargement to four diameters of the beak, showing the characters of the deltidium and foramen.

Fig. 4. Interior of ventral valve and a portion of the dorsal valve, showing the attachment of the cruræ.

c. Cruræ united by a loop.
p. Hinge-plate, or pedicle sheath.
t. Articulations.

The additional features of the loop represented in this figure have not, as yet, been satisfactorily determined; all the positive evidence indicates this to be the arrangement and development of the parts shown in figs. 1 and 2.

Rhynchotreta cuneata, var. Americana, *Hall.*

Plate 25, *Figs.* 29–38.

Rhynchotreta cuneata, var. *Americana*, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 167, pl. 25, figs. 29-38, 1879.

Shell triangular, cuneiform, longer than wide, greatest width near the front, and tapering posteriorly into an angular beak. Valves moderately convex, the dorsal sometimes gibbous; ventral beak elongated, foramen subcircular, formed by the extremity of the beak and a portion of the area below, which is separated from the hinge-line by a deltidium in two pieces; sides of the beak compressed, flat or concave. Sinus wide, deep or shallow, according to the development of the shell, commencing at one-third the length of the shell from the beak, and becoming very conspicuous in front. Dorsal valve the more convex, the mesial fold beginning as a depression just below the beak, and becoming very prominent on the lower half of the shell. Surface marked by nine or ten strong angular plications on each valve, of which three are depressed in the sinus, and four are elevated on the mesial fold—the two central ones being much the more prominent; the plications are crossed by numerous regular, fine thread-like striæ. The entire surface is minutely papillose.

This species is very common in the Waldron locality. The specimens are larger and in a better state of preservation than is usual in the New York localities.

Compared with its European congener, the American form is a more robust and larger shell, the surface marked by fewer and much stronger plications; while the transverse striæ are a little finer and less distant, and the sinus is much deeper and more abrupt.

Specimens from Waldron Indiana, from New York and from Dudley, England, have been cut on the dorsal side, and all show the crural processes, as in figure 1 of the accompanying illustrations.

ANASTROPHIA, *Hall.*

ANASTROPHIA INTERNASCENS, *Hall.*

Plate 26, *Figs.* 41–49.

Compare *Atrypa interplicata* (Sow.) Hall. Pal. N. Y., vol. ii, p. 275, pl. 57, figs. 2*a*, 2*g*. Not *Terebratula interplicata* (Sow.) Murch. Sil. Syst., p. 631, pl. 13, fig. 28.

Compare *Atrypa brevirostris?* (Sow.) Hall. Pal. N. Y., vol. ii, p. 278, pl. 58, figs. 1*a*, 1*f*. Not *Terebratula brevirostris* (Sow.) Murch. Sil. Syst., p. 631, pl. 13, fig. 23.

Compare *Pentamerus Verneuili*, Hall. Pal. N. Y., vol. iii, p. 260, pl. 48, figs. 1*a*, 1*y*.

Compare *Anastrophia Verneuili*, Hall. Pal. N. Y, vol. iv, p. 374.

Compare *Brachymerus*, Shaler. Bull. Mus. Comp. Zool, vol. i. 1865.

Anastrophia Verneuili, Hall. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 26, figs. 41, 49. 1876.

Anastrophia internascens, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 168, pl. 26, figs. 41–49. 1879.

Shell transversely subelliptical, ovoid or subglobose in different stages of growth, the proportions of length and width being sometimes nearly equal. Valves of young specimens nearly equal in convexity; in older ones the dorsal valve becomes the more gibbous.

Ventral valve moderately convex in young or medium-sized specimens, and gibbous in the upper part in older specimens; the anterior portion depressed and marked by a broad undefined sinus; beak short, acute, closely incurved over the umbo of the opposite valve; area small, short and sharply defined. Dorsal valve gibbous, and in old individuals the umbo projects beyond the beak of the ventral valve, with the apex incurved beneath the beak of the latter; central portion of the valve toward the front more elevated, and sometimes presenting a broad undefined mesial fold.

Surface plications abruptly elevated, rounded, angular or subangular, becoming depressed and sometimes obsolete on the cardinal slopes, usually simple, enlarging toward the front of the shell, rarely bifurcating or with an intercalated one on the middle of the shell, but bifurcating or intercalating in a remarkable manner on the sides, where the folds bend abruptly outwards to the cardino-lateral margins; plications crossed by arching imbricating striæ of growth, which are sometimes very conspicuous.

The individuals of this species measure from eleven to seventeen millimeters in length, from 12 to 19 mm. in width, and 9 to 12 mm. in depth.

This form from the Waldron locality, differs from the *Anastrophia* (*Atrypa*) *interplicata*, ut cit. of the Niagara group of New York in its larger growth, with more rounded or less angular plications, and in being almost free from intercalated plications, which are constant and characteristic in that species, and in having no defined mesial sinus, which is always a feature in the New York form. Similar features are described as characteristic of *A. brevirostris*. It is quite probable that these New York forms, which are described as two species, are in reality but varieties of the same.

Noting these differences between the New York specimens and those from Waldron, the latter was originally (*Transactions Albany Institute*, Vol. IV, p. 227), indicated as more nearly approaching to *A. Verneuili*, from the Lower Helderberg group in New York. They, however, present several marked differences; this form is smaller, more rounded and less ventricose; the umbones less prominent and not so closely incurved; the sinus rounded and undefined, never deep nor angular; the plications more rounded, generally continuous to the beaks, and occasionally increasing by implantation or bifurcation, while the latter is a constant character in *A. Verneuili*.

EICHWALDIA, *Billings*.

EICHWALDIA RETICULATA, *Hall*.

Plate 26, *Figs*. 50–54.

Rynchonella reticulata? HALL. Trans. Alb. Inst., vol. iv, p. 217. Abstract, p. 23. May, 186[illegible].

Eichwaldia reticulata, HALL. 20th Rep. St. Cab. Nat. Hist., p. 275. 1867.

Eichwaldia reticulata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 169, pl. 26. figs. 50–54. 1879.

Shell varying from elongate-triangular to transversely elliptical, gibbous in the upper part, more attenuate in front, cardinal slopes flattened in most specimens, sometimes rounded. Ventral beak small, acute, flattened on the back, and closely incurved; the front half of the ventral valve marked by a broad, shallow, sometimes undefined sinus. Dorsal valve usually more ventricose, beak obtusely pointed and strongly incurved, a low, broad, scarcely defined mesial elevation marks the center and often occupies nearly one-third the entire width of the valve; often this fold is obsolete, leaving the valve regularly arcuate from side to side, while in other specimens the borders are depressed and the shell flattened in front.

Surface of the shell, except a small space on the umbo of the ventral valve, covered by a finely reticulate marking, with elongate, generally hexagonal pits or openings, with thin and sharp ridges between; these markings vary in different specimens, and also on different parts of the same individual, being generally finest on the cardinal slopes. The small triangular space near the ventral beak, which is destitute of marking, has the appearance of having been exfoliated, but since this is an invariable character in all the individuals examined, varying in size with the size of the shell, it is probably dependent upon organic causes.

This species resembles *Eichwaldia coralifera*, Pal. N. Y., Vol. II, p. 281, but differs in being much broader and less ventricose, and also in the greater breadth and less prominence of the mesial fold.

LAMELLIBRANCHIATA.

AMPHICŒLIA, *Hall.*

AMPHICŒLIA LEIDYI, *Hall.*

Plate 28, *Fig.* 1 *and Fig.* 2?

Amphicœlia Leidyi, HALL. 20th Rep. St. Cab. Nat. Hist., p. 339, pl. 14, figs, 13-15. Rev. edit., p. 387.

Amphicœlia Leidyi, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 171, pl. 27, fig. 1 and 2? 1879.

The specimens from Waldron, which are referred to this species, are in the condition of casts of the interior, and are more or less flattened in the soft shales. The fossil preserves the usual rhomboidal form of the species; the beak is much elevated, and this feature, in the specimen fig. 1, is apparently increased by the pressure to which the shell has been subjected. The hinge-line is more oblique than in the typical forms of the species, but this may be due to pressure.

The casts preserve some remains of concentric striæ, but there is no evidence of the fine radiating striæ which are characteristic of the genus. The length of the shell is equal to the height, as shown in specimens from other localities.

The specimen fig. 2, has a length greater than the height, the beak is less elevated and at a greater distance from the anterior margin, giving a more equilateral aspect to the fossil. This may be a distinct species, but owing to the condition in which the specimens occur, it would be impossible to indicate specific characters beyond the general form of the shell.

Almost all the specimens of Lamellibranchiata from the Waldron locality are in the condition of casts of the interior, the shell having been dissolved, while the shaly material, with which it was filled, preserves the characters in a very imperfect manner.

AMBONYCHIA ACUTIROSTRA, *Hall.*

Plate 27, *Figs.* 28, 29.

Ambonychia acutirostra, HALL. 20th Rep. St. Mus. Nat. Hist., p. 336, pl. 14, fig. 2. 1867; Rev. edit., p. 383.

Ambonychia acutirostra, HALL. Under reference to *Sagenella elegans*. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 7, fig. 12. 1876. Mus. edit., p. 171. 1879.

Shell narrow ovate, subequilateral, length nearly twice the width; valves moderately convex, sloping very abruptly to the anterior margins; posterior margins flattened; beak acute, not elevated, projecting beyond the cardinal margin; cardinal line straight. Substance of shell very thin, showing lamellose lines of growth; margin depressed, crenulated from the impression of the surface striæ.

Most of the specimens are obscure casts of the interior, and present few characters beyond the general form.

Compared with *A. aphæa*, HALL, a species with which it is associated in Wisconsin and Illinois, it is longer, with the beaks more elongate and attenuate. In many respects it resembles the *Myalina mytiliformis*, HALL, of the Clinton group (Pal. N. Y., Vol. II, p. 100); but it is proportionately wider, and the beaks more attenuate.

MODIOLOPSIS, *Hall.*

MODIOLOPSIS PERLATUS, *Hall.*

Plate 28, *Figs.* 3, 4.

Modiolopsis perlatus, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 27, figs. 3, 4. 1876. Mus. edit., p. 172. 1879.

Shell ovate, moderately convex, the greatest convexity a little anterior to the middle of the shell. Beaks slightly elevated above the hinge-line and scarcely more than one-fifth the length of the shell from the anterior end, the greatest width of the shell about midway between the beak and the posterior extremity. The straight hinge-line extends about half the distance from the beak to the posterior extremity, thence curving into the posterior slope. Basal margin a little contracted immediately below the beak, and thence curving into the broadly rounded posterior extremity. Surface marked by fine lines of growth with a few stronger undulations.

Length of the shell three and a half centimeters; width two and a half centimeters.

This shell differs from characteristic forms of *M. subalatus* in the more ascending direction of the hinge-line from the beak, the broader and more regularly rounded posterior extremity, and the lesser constriction of the basal margin beneath the beak.

MODIOLOPSIS SUBALATUS, *Hall.*

Plate 28, *Figs.* 5, 6.

Modiolopsis subalatus, HALL. Pal. N. Y., vol. ii, p. 84, pl. 27, figs. 5 and 6. 1852.
Modiolopsis subulatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 173, pl. 27, figs. 5, 6. 1879.

Shell rhomboidal ovate, the proportions of length and breadth varying in different individuals, one of the specimens figured having a length once and three-fourths as great as the width, while the other is less than once and a half as long as wide. Hinge-line equaling or greater than one-half the length of the shell; umbo prominent, beak moderately elevated above the cardinal line; posterior side broadly rounded and subalate above; anterior side narrow, rounded or subacute; basal margin anterior to the center, and nearly beneath the beak, more or less distinctly arcuate. Surface marked by fine concentric lines of growth.

Length of shell thirty-one to thirty-seven millimeters; greatest width 22 to 23 mm.

The specimens from Waldron are much larger than those known in New York, but they are in other respects similar. Without a greater amount of material for comparison, a special specific distinction is not warranted.

MYTILARCA, *Hall.*

MYTILARCA SIGILLA, *Hall.*

Plate 28, *Fig.* 10.

Mytilarca sigilla, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 28, fig. 10. 1876. Mus. edit., p. 174. 1876.

Body of the shell ovate-acute, broadly rounded at the base alate posteriorly; hinge line oblique. Length sixteen millimeters.

The specimen is a cast of the interior, and the surface-markings are unknown.

PTERINEA, *Goldfuss.*

PTERINEA BRISA, *Hall.*

Plate 27, *Figs.* 24, 25; *Plate* 28, *Figs.* 7--9.

Pterinea brisa, HALL. 20th Rep. St. Cab. Nat. Hist., p. 337, pl. 14, fig. 1. 1867. Rev. edit., p. 384. 1870.

Pterinea brisa, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 173, pl. 27, figs. 7--9. 1879.

Compare *Avicula emacerata*, (CONR.) HALL. Pal. N. Y., vol. ii, p. 282, pl. 59, figs. 1*a*-1*e*. 1852.

Compare *Ambonychia* (*Pterinea*) *striæcostata*, McCHESNEY. New. Pal. Foss., p. 88, pl. 9, fig. 4; and Trans. Chic. Acad. Sci., vol. i, p. 88, pl. 9, fig. 4. 1869.

Body of shell (left valve) obliquely subovate, extremely inequilateral; anterior wing moderately extended and strongly sinuate at its junction with the body; posterior wing not extending as far as the posterior extremity of the shell; umbo prominent, beak rising a little above the hinge-line; muscular impression in right valve large and nearly round, near the middle of the length of the shell. In the casts, beneath or just anterior to the beak, there is one short curving dental pit, with a smaller accessory one. This is a feature not observed in the Waldron specimens, which are usually found as the exteriors and often as imperfect interiors of the valves; the few casts which have been observed from this locality, do not show the muscular marking.

Surface marked by strong radiating and concentric striæ, with broad, little elevated, radiating ribs. The concentric striæ of growth are produced into prominent, recurving, fimbriated laminæ, the fimbriæ being infolded at their margins and bending backward in the form of long, hollow, semicylindrical spines, leaving a broad sinus between, in the bottom of which is a shorter spine. The younger specimens, as usually preserved, present simple fimbriated lamellæ.

GONIOPHORA, *Phillips.*

GONIOPHORA SPECIOSA, *Hall.*

Plate 27, *Figs.* 26, 27.

Goniophora speciosa, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 17. 1879.

Shell subrhomboidal, a little more than twice as long as wide; hinge-line two-thirds the length of the shell; anterior extremity somewhat obliquely truncated; a prominent angulation extending from the beak to the posterior basal margin. Surface marked by striæ of growth which are parallel to the margins of the shell, being gently curved below the carination, and above it turning forward parallel to the truncate posterior margin. Length of specimen eighteen millimeters.

CYPRICARDINIA, *Hall.*

CYPRICARDINIA ARATA, *Hall,*

Plate 27, *Fig.* 23.

Cypricardinia arota, HALL. 20th Rep. St. Nat. Hist., p. 337, plate 14, fig. 6. 1867. Rev. edit., p. 385. 1870.

Cypricardinia arata, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 174. 1879.

Compare *Cypricardinia subovata*, MILLER & DYER. Contributions to Palæontology, No. 2, 1878.

Shell subovate, varying from moderately to extremely gibbous, slightly alate at the postero-cardinal margin; beaks near the anterior end, which is short and rounded. Surface marked by strong concentric lamellose ridges.

In form, this species resembles *Modiolopsis* (*Cypricardinia*) *undulostriata* of the Niagara shale of New York; but the concentric ridges are stronger, and the fine undulating striæ are not visible in any of the western specimens.

The specimens from Waldron present no marks of specific distinction from those of the Niagara limestone of Wisconsin.

GASTEROPODA.

PLATYOSTOMA, *Conrad.*

PLATYOSTOMA NIAGARENSE, *Hall.*

Plate 29, *Figs.* 1-12; *Plate* 30, *Figs.* 1-15.

Platyostoma Niagarensis, HALL. Pal. N. Y., vol. ii, p. 287, pl. 60, figs. 1*a*–1*v*. 1852.
Platyostoma Niagarense, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 175, pl. 28, figs. 1-12; pl. 29, figs. 1-15. 1879.

Shell ovoid or subglobose, volutions three to four, the last one very ventricose, spire varying from the plane of the outer volution to an elevation of one-fifth or one-fourth the height of the shell above.

Apex minute, somewhat rapidly expanding, the first two volutions usually symmetrical; the outer volution often unsymmetrical, very ventricose and regularly rounded upon the back, but not unfrequently extended and becoming free toward the aperture, and marked on the upper or lower side, or upon both, by a groove, along which the striæ are abruptly bent, indicating a sinus in the peristome during some period of its growth; peristome entire or undulated, sometimes distinctly notched in the margin, free or adhering on the columellar side and sometimes expanded and presenting a thickened callosity or columellar lip.

Surface marked by fine undulating striæ of growth, which sometimes become lamellose. In well-preserved specimens, finer revolving striæ cancellate the striæ of growth, and sometimes the surface is marked by revolving ridges.

The principal varieties of form and mode of growth are illustrated on plates 29 and 30. The large collections present numerous intermediate forms and varieties of surface-marking.

PLATYOSTOMA PLEBEIUM, *Hall.*

Plate 29, *Figs.* 14, 15.

Platyostoma plebia, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 28, figs. 14, 15. 1876.

Platyostoma plebeium, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 175, pl. 28, figs. 14, 15. 1879.

Shell dextral, conical; volutions four, very convex, gradually increasing in size from the apex, the last volution free for a short distance above the aperture, the back sometimes flattened; aperture broadly elliptical, opening nearly parallel to the axis of the shell, without proper umbilicus; suture-line deeply impressed, leaving more than three-fourths of the height of the volution exposed.

Surface marked by fine transverse striæ of growth, which are usually quite regular, but sometimes abruptly arching forward on the middle of the last volution, and receding above and below, in conformity to sinuosities in the lip.

This species is distinguished from *P. Niagarense* by the more elevated spire, and by the form and relative position of the aperture. The surface-markings are also usually finer than in that species.

STROPHOSTYLUS, *Hall.*

STROPHOSTYLUS CYCLOSTOMUS, *Hall.*

Plate 31, *Figs.* 1-13.

Strophostylus cyclostomus, HALL. Trans. Alb. Inst., vol. iv, p. 218. Abstract, p. 24; May, 1863.

Strophostylus cyclostomus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist; Mus. edit., p. 176, pl. 30, figs. 1-13. 1879.

Shell subglobose or transversely broad oval. Spire moderately elevated; volutions about four, rounded, the last one extremely ventricose and very much extended on the upper side and at the sutural margin. Aperture circular or subcircular, very oblique to the axis; peristome thin, entire, without sinus or emargination, spreading over the surface of the next volution, rarely leaving a slight umbilicus. Columellar lip grooved in the lower part, with a rather strong spiral fold at about one-third the diameter from the lower side of the aperture. Suture not canaliculate.

Surface marked by strong, crowded lamellose striæ of growth parallel to the margin of the aperture, and by much finer revolving, undulating lines, producing a finely cancellate structure in well-preserved specimens.

This species, in the elevation of the spire, differs from any other described form of the genus, except *S. elegans* of the Lower Helderberg, and from that one in being more ventricose and more oblique.

STROPHOSTYLUS CYCLOSTOMUS, var. DISJUNCTUS, *Hall.*

Plate 31, *Figs.* 14 *and* 13.

Strophostylus cyclostomus? HALL. Doc. edit., 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 30, figs. 14, 15. 1876.

Strophostylus cyclostomus, var. *disjunctus*, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 177, pl. 30, figs. 14, 15. 1879.

The earlier volutions of this fossil have the characters of form and surface-markings of *S. cyclostomus;* but the last volution is less expanded, and becomes entirely disjoined toward the aperture, preserving no evidence of columellar lip or thickening of the peristome.

The surface-markings are characteristics of the genus.

LOXONEMA ———?

Loxonema ———? HALL. Trans. Alb. Inst., vol. x. Abstract, p. 17, 1879.

Compare *Loxonema leda*, HALL. 20th Rep. St. Mus. Nat. Hist., p. 346. 1867.

Several specimens referred to this genus have been observed, consisting entirely of casts of the interior. They do not possess sufficiently well defined characters to designate them as a species or to refer them to any described form.

BELLEROPHON, *Montfort.*

BELLEROPHON TUBER, *Hall.*

Plate 31, *Figs.* 19, 20; *Plate* 33, *Fig.* 6.

Bellerophon tuber, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 30, figs. 19, 20. 1876. Mus. edit., p. 177. 1879.

Shell convolute, subglobose, height and width about equal. Aperture expanded, broadly reniform, bilobate, with a broad sinus on the dorsal margin. Dorsum subcarinate toward the aperture.

Surface marked by fine striæ parallel to the lines of growth, commencing at the umbilicus and curving broadly over the side of the shell, and somewhat abruptly recurved on the dorsum.

This species is the only Bellerophon proper which has come under observation from the Niagara group. The specimens of this species from Waldron are very imperfect, all of them having been macerated, and usually deprived of the shell. The example figured is less expanded than some others, from later collections, which are likewise distinctly carinate on the dorsum near the aperture.

CYRTOLITES, *Conrad*.

CYRTOLITES SINUOSUS, *Hall*.

Plate 31, *Figs*. 16, 18.

Cyrtolites sinuosus, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 30, figs. 16–18. 1876. Mus. edit., p. 178. 1879.

Shell convolute, volutions in the same plane, contiguous. Body of the shell strongly lobed, the dorsum being separated from the lateral portions of the shell by a distinct groove or sinus on each side. Aperture elongate, subquadrate, auriculate at the sides, and the peristome deeply sinuated in front.

The specimens of this species are casts of the interior, and the surface-markings are unknown. This form may be compared with *Bucania trilobata*, of the Medina Sandstone and Clinton group, but it is less gibbous, more abruptly trilobate, and is marked by a deep abrupt sinus in the anterior margin of the peristome—a feature not known in that species.

PTEROPODA.

CONULARIA, *Miller*.

CONULARIA INFREQUENS, *Hall*.

Plate 33, *Fig*. 7.

Conularia infrequens, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 17. 1879.

Cone strong, marked by prominent transverse ridges, with intermediate furrows, which are gently curved; ridges crossed by numerous strong nodes, which are slightly elongate in a direction transverse to the ridges, and perceptibly wider at their lower extremities; about ten of these nodes in the space of four millimeters in the line of the ridges. The intermediate furrows are marked by one or two longitudinal striæ.

This species is larger and the surface-markings coarser than *C. Niagarensis.* In general aspect and surface-marking it may be compared with *C. longa* and *C. lata*, but the cone has apparently been wider than the first of these and not so expanded as the last. No entire individual has been seen.

COLEOLUS, *Hall.*

COLEOLUS SPINULUS, *Hall.*

Plate 33, *Fig.* 8.

Coleolus spinulus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 18. 1879.

Form a very slender, elongate cone, slightly curving near the apex. Section circular. Length from two to eight millimeters. Surface ornamented by fine, sharp, annulating, regular striæ, fifteen to twenty in the space of 1 mm.

This is the only species yet described from Silurian rocks. Specimens are found in considerable numbers in the softer portions of the shale associated with LEPERDITIA, BEYRICHIA, and other minute forms which are obliterated in the coarser or pyritiferous shales.

The specimens are very much smaller than those of any species of this genus yet described. *C. tennicinctum* and *C. aciculum* from the Hamilton group of New York, reach a length of 75 mm.

CEPHALOPODA.

ORTHOCERAS, *Breynius.*

ORTHOCERAS SIMULATOR, *Hall.*

Plate 28, *Figs.* 11, 12; *Plate* 33, *Figs.* 1, 2.

Orthoceras simulator, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 28, figs. 11, 12. 1876. Mus. edit., p. 179. 1879.

Shell cylindrical, gradually enlarging, siphuncle subcentral; septa distant from each other about one-fourth of the diameter of the shell, from three to four in the space of fourteen millimeters.

Surface finely striated transversely.

The diameter of the largest specimen observed is 25 mm.

The specimens are frequently flattened and in a very bad condition of preservation, the shell being entirely destroyed, and usually the septa are obliterated.

ORTHOCERAS MEDULLARE, *Hall.*

Orthoceras medullare, HALL. Rep. Prog. Geol. Surv. Wis. 1860.
Orthoceras strialineatum, MCCHESNEY. New Pal. Foss. p. 94. 1861.

Shell circular in its transverse diameter, often a little compressed, regularly and gradually enlarging to the aperture. Septa distant nearly half the diameter of the tube, but subject to considerable variation in the same individual, so that nearly three chambers are sometimes included in a length equal to the diameter. The siphuncle is large and slightly expanded between the septa.

Surface marked by strong, sharp, subequal, longitudinal lines, which are cancellated by fine transverse striæ. The longitudinal striæ are often alternated by finer, sharp striæ in the same direction. Surface of the cast smooth, and by this character it is distinguished from the casts of *O. subcancellatum* and *O. annulatum.*

This species, described in the 20th *Report on the New York State Museum of Natural History*, is of frequent occurrence in the Magnesian Niagara limestone of Wisconsin; several specimens have been observed in the Waldron collections. It usually occurs in an imperfect and much macerated condition; only one specimen has been observed which preserves distinctive characters.

ORTHOCERAS SUBCANCELLATUM, *Hall.*

Plate 33, *Fig.* 5.

Orthoceras cancellatum, HALL. Pal. N. Y. vol. ii, p. 292. 1852.
Orthoceras subcancellatum, Hall, S. A. MILLER. Cat. Am. Pal. Foss., p. 245. 1877.
Not *Orthoceras cancellatum*, EICHWALD. 1842.

Shell medium-sized, circular in transverse section. Air-chambers having a depth of more than one-half the diameter of the tube. Sutures straight and horizontal. Siphuncle unknown.

Surface ornamented with longitudinal angular ridges, and intermediately by finer longitudinal striæ, which are crossed by finer equal striæ, giving a cancellated appearance to the surface.

Specimens of this species are quite rare at Waldron, and do not show the concentric striæ of ornamentation, being in the condition of casts of the interior, and only preserving the longitudinal ridges and lines.

ORTHOCERAS ANNULATUM, *Sowerby.*

For citations, see Pal. N. Y., vol. ii, p. 293.

Shell large, very gradually enlarging; transverse section circular. Air-chambers having a depth equal to from one-third to one-fourth the dimeter of the tube. Septa smooth, with a concavity equal to the depth of the air-chambers. Sutures straight, horizontal, situated between the summits of the annulations. Siphuncle subcentral, not expanding in the cavities of the air-chambers.

Tube ornamented with strong rounded annulations, which are usually straight and horizontal, but in some older individuals become curved and oblique. These annulations are of about the same frequency as the septa. Surface marked by undulating, and more or less imbricating lamellae of growth.

Specimens are not unfrequent in the softer shales, but their condition of preservation does not permit satisfactory observation to be made of their essential specific characters. Several individuals from the limestone preserve their normal form and show the septa and siphuncle, which is somewhat unusual with specimens of this species.

ORTHOCERAS AMYCUS, *Hall.*

Plate, 33, *Figs.* 3, 4.

Orthoceras amycus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 18. 1879.

Shell very gradually and almost imperceptibly enlarged from the apex; section circular; septa deeply concave, distant from each other nearly two-thirds the diameter of the tube; siphuncle central or slightly excentric, diameter at the septum one-sixth the diameter of the tube; marked by low rounded annulations which are slightly oblique to the axis of the shell, two to three annulations in the space of one chamber; twenty-four annulations in the space of one hundred millimeters.

Surface marked by fine concentric striæ which follow the direction of the annulations: no longitudinal striæ have been noticed.

This species differs from *O. annulatum* in the more gently tapering tube, the greater distance of the septa, the low undefined annulations, and the fine concentric striæ which are not lamellose, and in the absence of longitudinal striæ.

NAUTILUS, *Breynius.*

NAUTILUS OCEANUS, *Hall.*

Nautilus Oceanus, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 19. 1879.

Shell large, discoidal; volutions closely coiled but not reentrant; umbilicus large and open; transverse section elliptical, the dorso-ventral diameter being the greater. Shell gradually enlarging.

Chamber of habitation large; length twice the greater diameter, the capacity being equal to, or greater than, the entire septate portion of the shell; becoming straight, and free from the inner volutions, toward the aperture. Septa regular, two in the space of five centimeters on the ventrum, and five in the same space on the dorsum.

The specimens measure from twenty to twenty-five centimeters in diameter.

This species resembles *N. occidentalis* of the Niagara group of Wisconsin, but the form is less gibbous and the septa less distant than in that species.

GYROCERAS, *DeKoninck.*

GYROCERAS ABRUPTUM, *Hall.*

Gyroceras abruptum, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 19. 1879.

Shell coiled, rapidly expanding toward the aperture: number volutions about one and a half ?, not contiguous. Transverse section broadly elliptical or subcircular; dorso-ventral diameter the longer. Septa distant, the distance between them becoming gradually greater from the apex toward the chamber of habitation. The last three chambers measure on the ventral side sixty-five millimeters, and on the dorsal side about 24 mm. Siphuncle near the ventral side.

Surface cancellated by longitudinal furrows, about 1 mm. wide, which are crossed by finer strong lines of growth.

The specimen described has had a diameter of about fifteen centimeters.

This species in a fragmentary condition, may be distinguished from *Nautilus Oceanus* with which it is associated, by its smaller size, more distant septa, and more rapidly expanding form.

TROCHOCERAS, *Barrande-Hall.*

TROCHOCERAS WALDRONENSE, *Hall.*

Plate 28, *Figs.* 13-15.

Trochoceras Waldronense, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 27, figs. 13-15. 1876.

Trochoceras Waldronense, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 179, pl. 27, figs. 13-15. 1879.

Shell dextral, making about two volutions; spire depressed, volutions slightly flattened; section subelliptical; gradually expanding, and the outer chamber continued in a more direct line; siphuncle excentric, nearer to the concave dorsal margin; septa moderately convex.

Surface marked by strong annulations, which are oblique and abruptly curved backward on the convexo-ventral side, very gradually increasing in distance from each other, to the outer chambers, beyond which the shell is marked by gentle undulations or lines of growth; the space between the annulations regularly concave. In well preserved specimens (seldom in others) there are finer surface markings consisting of longitudinal striæ of which there are five in the space of one millimeter; these are crossed by finer concentric striæ.

This species differs from any known form in the Niagara group, by its more slender and gradually enlarging volutions.

ANNELIDA.

SPIRORBIS, *Lamarck*.

SPIRORBIS INORNATUS, *Hall*.

Plate 32, *Figs*. 14, 15.

Spirorbis inornatus, HALL. Trans. Alb. Inst., vol. iv, p. 224. Abstract, p. 30; May, 1863; including *Spirorbis? flexuosus*, HALL. Trans. Alb. Inst., vol. iv, p. 224. Abstract, p. 30; May, 1863.

Spirorbis inornatus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 181, pl. 31, figs. 14, 15. 1879.

Convolute, discoid, adhering, deeply depressed or umbilicate, consisting of about two volutions, the outer one robust, transverse diameter the greater, margin subangular.

Surface smooth or with lines of growth which on the exposed edge of the volution sometimes become slight ridges.

The specimens of this species are comparatively numerous, but the greater part are without distinctive surface-markings, or incomplete in their volutions.

In a single specimen observed, the tube, after making about one volution and a half in contact, becomes free, assuming a sinuate or spiral direction, extending about two millimeters from the point of divergence, and somewhat rapidily enlarging to the outer extremity, which is imperfect; in other respects this form has the character of *Spirorbis inornatus*. A similar feature has already been illustrated in *Spirorbis laxus* of the Lower Helderberg group. (Pal.N.Y.,Vol.III, page 349, plate 54, fig. 18).

The original specimens described as *Spirorbis? flexuosus* are not now accessible, but it is presumed that they were similar to the one referred to, with the outer volution becoming free and continuing in a sinuate or direct line, and are probably not distinct from *S. inornatus*.

CORNULITES, *Schlotheim*.

CONCHICOLITES, *Nicholson*.

ORTONIA, *Nicholson*.

CORNULITES PROPRIUS, *Hall*.

Plate 32, *Figs*. 1-13.

Cornulites proprius, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 32, figs. 1-13. 1876. Mus. edit., p. 182. 1879.

Elongate-tubular, obconical or trumpet-shaped bodies, rapidly enlarging toward the aperture, which is campanulate with the margins always imperfect. Surface in the young usually sharply annulated and longitudinally striated; the section subcircular, a little flattened on the adhering side.

These bodies in their young state are parasitic (adhering to other organic bodies), occurring as slender tubes, which are more or less curved or undulating, and rarely straight for a considerable portion of their length; the apices, when entire, are abruptly curved, often making half a volution or more; growing singly or in groups of two or more (as shown in figures 1–3, pl. 32), and conforming to the contour of the surface, to which they are attached for a varying distance of ten to twenty millimeters or more, and then becoming free, either by extending in a direct line and rising above the surface, or growing beyond the limits of the object to which the germ was attached, and continuing their growth; or becoming separated, leave the adhering basal portion, which is always imperfect or broken at the margins of the open extremity.

This is the prevailing and almost universal condition of these bodies in their ealier stages of growth. The minute apex finally becomes solid, is absorbed, or otherwise disappears; the remaining tubular portion gradually loses its evenly annulated character in the progress of growth, the substance of the tube becomes thickened, the rings broader, less defined or obsolescent, merging into a generally undulating or subimbricating surface, which is marked by numerous thin irregular annulating ridges, sharply crenulated by the longitudinal striæ. In this condition the lower or early portions of the fossil are rarely preserved, the lower extremity being usually broken or sometimes cicatrized, having become free from the original attachment and continuing as an independent body the form of a straight, trumpet-shaped tube. Many of them, however, still adhere to the original surface till they have acquired a large size (depending in some degree upon the nature and extent of the surface to which they are attached), as shown in fig. 5 of plate 32; the lower extremity has here become thickened, and the annulated character obsolete.

The annulations, so well defined in the younger stages of growth, affect the interior of the tube, which is enlarged at these points; and from the interannular spaces, there are thin lamellæ projecting into the interior, and for some distance across the cavity of the tube. In some phases of wearing or decortication, these lamellæ give a partially septate character to the fossil; and it is due to the same cause that we have the annulated casts of the interiors, where the sharp constrictions mark the place of these projecting lamellæ. The same feature occurs in all the species, and where the small parasitic tubes become worn down they present a septate appearance.

In the young state, the annulations and the interior projecting lamellæ are alternate and corresponding in number; but as the exterior becomes thickened and its growth irregular, the interior continues essentially uniform, and the projecting lamellar septa maintain much regularity in their occurrence. The thickening of the walls, and the irregularity of growth, is confined to the exterior, while the cavity of habitation maintains a regularly increasing size, very rarely encroached upon by the cellular tissue.

The interior structure of the walls is vesicular, but these walls vary greatly in thickness in specimens externally of the same size, as may be seen by comparing figures 9 and 10 of plate 32. Even the smaller parasitic tubes, like those of figures 1, 2 and 3, show a vesicular wall structure, although this is often limited to one or two ranges of vesicles; and the same is sometimes true of the larger specimens, as shown in figure 10, and in figure 11, where the wall on one side is thin and nearly or entirely destitute of cellular tissue. This texture is not only variable in extent, but also in the form of the vesicles (as shown in figures 12 and 13), and it sometimes so far invades the interior wall as partially to obliterate the evidence of annulations, as in the specimen figure 13, where this cellular tissue has formed upon the inner face of the tube.

Since this fossil occurs in such different phases (the prevailing one of which is shown in figures 1–3, and another in figures 4–7,) the identity is not readily observed; but a study and comparison of a large number of specimens has left no doubt of their identity; the different forms being simply the different stages of growth of the animal, which in its young state is parasitic, becoming free above and rapidly increasing in size in its later stages.

This manifestation of development, here illustrated, corresponds in all respects with the figures given by Sir R. I. Murchison in his *Silurian System*, as cited in a previous note, except that we do not possess casts of the interior, which are there illustrated in a very beautiful manner. Similar casts of another species are illustrated on plate 28, figs. 12, a, c, d, e, Pal. N. Y., Vol. II. The Waldron specimens, in their young condition, closely resemble those from Dudley in England, as they occur attached to the shells of PENTAMERUS and MERISTELLA.

The similarity of CORNULITES, in its young state, with TENTACULITES, has led to the reference of these bodies to the latter genus, and in some of their phases it is not easy to make the distinction.* The Tentaculites in all stages of growth, so far as we know, have been free floating shells; but CORNULITES is always parasitic in its young state at least, and may either

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*See illustrations, *Pal. N. Y. vol. v, pl. ii, p. 115.*

become free or remain attached throughout its existence. Some of the forms heretofore known as TENTACULITES in rocks of the Hudson River group in the Western States, and possessing all the external characters of that genus, have also the vesicular texture belonging to CORNULITES; and a more critical study of some of the species has shown them to be parasitic and gregarious in their earlier stages of growth. We have long known that *Tentaculites flexuosus* (Pal. N. Y., Vol. I,) is a CORNULITES, and these facts have induced us to review some other species published as TENTACULITES.

Tentaculites flexuosus, ut cit. will therefore be placed under CORNULITES=*C. flexuosus*, a species growing singly or in groups, as illustrated in the original figures, *Pal. N. Y.*, Vol. I, pl. 29, and of which we know nothing regarding its later stages, corresponding to the larger growth of *C. proprius*.

The figure described in the same volume, page 284, pl. 78, is apparently a distinct species; and the specimens from western localities, considered identical with that from the Hudson river group of New York, have since been described under other names.

The form described as *Cornulites flexuosus* (*Pal. N. Y.*, Vol. II, p. 98, pl. 28,) is a true CORNULITES, the specimen 12a retaining a portion of the test, but preserving no distinct exterior annulations, while the other figures are casts of the interior. Since the specific name *flexuosus* is preoccupied, the name *Cornulites Clintoni* is proposed.

This species is allied to the *C. arcuatus* of Conrad, from the Niagara limestone of New York, in which the annulations of the cast are more rounded, and the shell more rapidly tapering.*

An examination of the original specimens of *T. distans*, of the Clinton group, proves it to be a CORNULITES, and it will therefore be indicated as *Cornulites distans*.

**Jour. Acad. Nat. Sci. Phil., vol. viii, p. 276, pl. 17, fig. 8.*

CRUSTACEA.

LEPERDITIA, *Roualt.*

LEPERDITIA FABA, *Hall.*

Plate 34, *Figs.* 1-3.

Leperditia faba, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 34, figs. 1-3. 1876. Mus. edit., p. 186. 1879.

Form subovate, gibbous, greatest convexity just anterior to the middle; hinge-line straight and equaling two-thirds the length of the shell; width of the shell equal to three-fifths of the length; valves subequal, the left valve the larger and overlapping at the base; posterior end rounded, narrower than the anterior; base broadly and regularly rounded in outline, the line of junction of the two valves being slightly arcuate laterally.

Surface apparently smooth.

BEYRICHIA, *McCoy.*

BEYRICHIA GRANULOSA, *Hall.*

Plate 34, *Fig.* 4.

Beyrichia granulosa, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 34, fig. 4. 1876. Mus. edit., p. 186. 1879.

Form broadly semi-oval; dorsal side straight; anterior and posterior lobe unequal; the ventral, anterior and posterior sides bordered by a broad flattened rim; subcentral node ovate, extending three-fifths the width of the test, and about one-fourth as wide as the length of the shell.

Surface finely tuberculate.

CALYMENE, *Brongniart.*

CALYMENE NIAGARENSIS, *Hall.*

Plate 34, *Figs.* 8-15.

Calymene Niagarensis, HALL. Geol. N. Y. Surv. 4th Geol. Dist., p. 101, fig. 3, and p. 102. 1843.

Calymene Blumenbachii, var. *Niagarensis*, HALL. Pal. N. Y., vol. ii, p. 307, pl. 67, figs. 11 and 12. 1852.

Calymene Niagarensis, HALL. 20th Rep. St. Cab. Nat. Hist., p. 400; Rev. edit., p. 425.
Calymene Niagarensis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 187, pl. 32, figs. 8–15. 1879.
For synonymy of the species, see Pal. N. Y., vol. ii, p. 307.

General form ovate. Head semi-circular or sublunate. Glabella marked by three tubercles on either side, the lower pair being much more prominent than the others. Thorax gradually tapering from the base of the head; composed of thirteen articulations, those of the middle lobe being bent abruptly upwards at their extremities, which are prominent; articulations of the lateral lobes compressed and rounded towards their extremities, with a distinct longitudinal groove reaching nearly their whole length, but usually visible only about half their length, or to the arching of the ribs. Pygidium with about eight articulations in the middle lobe, and five in each lateral lobe, those of the lateral lobes grooved nearly to the margin, which is thickened and reflexed. Surface granulated.

This species is the most abundant form among the trilobites of the Waldron locality. The specimens present no modification of characters from those in the Niagara shale of New York, although they are usually of larger size. A large proportion of the idividuals in the earlier collections, are fragmentary, having been macerated upon the sea bottom before they were covered by the sediments. In the collections recently made are several individuals which preserve all the parts entire.

This species is associated with CYPHASPIS, HOMALONOTUS, ILLÆNUS, LICHAS and DALMANITES.

HOMALONOTUS, *Konig*.

HOMALONOTUS DELPHINOCEPHALUS, *Green*.

Plate 34, *Figs*. 17, 18.

Trimerus delphinocephalus, GREEN. Monograph of Trilobites, p. 82, pl. 1, fig 1. 1832.
Homalonotus delphinocephalus, (GREEN) HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 187, pl. 32, figs. 17, 18. 1879.
For synonymy and other references, see Pal. N. Y., vol. ii, p. 309.

Head ovate or subtriangular, arcuate at the base, more or less convex in the middle, and depressed in front, often subacute at the extremity. Glabella scarcely defined; margin around the front often elevated. Posterior margin of the buckler marked by a strong continuous ridge. Facial suture in front, parallel and coincident with, or slightly within the flexure of the margin, passing thence obliquely through the eye, and turning, comes to the margin a little above the posterior angle. Segments of the thorax thirteen, continuous central lobe broad, scarcely defined; articulations with a broad deep groove or furrow running nearer to the anterior margin, and continuing across the axis and into the lateral lobes to the point where they bend downwards, below which it is a sharp impressed line. Lateral articulations falciform, flattened, much expanded and rounded at the extremities, anterior margin arcuate. Pygidium triangular, acute and acuminate at the extremity; middle lobe with eleven to thirteen articulations. lateral lobe with seven to nine articulations. Surface granulose or scabrous.

This species is distinguished by the distinct trilobation of the tail in all its stages of growth, as well as by the comparatively more slender and elongated form of the body, and more acute caudal extremity.

This species occur in the Waldron locality, mostly in a fragmentary condition. One specimen preserving the head and thorax nearly entire has been observed. Exclusive of this specimen, the species is only represented by fragments of the cephalic and caudal shields. These portions of the fossil bear all the characteristic marks of identity with those from the Niagara shale in New York.

CYPHASPIS, *Burmeister.*

CYPHASPIS CHRYSTYI, *Hall.*

Plate 34, *Figs.* 5-7.

Cyphaspis Chrystyi, HALL. Trans. Alb. Inst., vol. iv, p. 220. Abstract p. 26; May, 1863.

Cyphaspis Chrystyi, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 188, pl. 32, figs. 5-7. 1879.

General form of body elongated-oval, the length nearly twice the greatest width of the thorax.

Head semi-oval, the posterior margin slightly concave, highly elevated in the middle, bounded by a proportionally strong thickened rim, the posterior angles being prolonged into slender spines reaching to the sixth or seventh thoracic segment, and slightly divergent. Glabella small, broad-ovate, rounded in front and truncate behind, about half the length of the head, greatest width anterior to the middle; surface convex, very prominent behind, some specimens showing faint indications of a pair of short oblique furrows anterior to the middle; near the base on each side a small ovate node separated from the glabella by a distinct furrow; longitudinal furrows moderately deep. Eyes small, very prominent and rounded, situated about one-third the length of the head from the posterior margin; distance from center to center equal to the length of the head forward to the occipital furrow; the surface smooth. Occipital ring narrow, the furrow well marked, becoming less distinct toward the posterior cheek furrows. Cheeks not prominent except anteriorly.

Thorax with twelve segments, highly convex, deeply lobed, lobes nearly equal in the anterior portion; the axial lobe more rapidly tapering posteriorly than the lateral ones, its annulations curved forward in the middle; lateral segments curved a little backward, the extremities obtusely rounded, somewhat abruptly bent a little nearer the axial extremity, causing an angular ridge along each lateral lobe; each segment marked by a strong longitudinal furrow nearer the anterior margin.

Pygidium small, subsemi-circular, a little arched forward on the anterior border; axial lobe extending a little more than two-thirds the length of the pygidium, rounded at the extremity and marked by one distinct and one indistinct annulation, as also in the lateral lobes. Surface marked by small scattered pustules, most distinct on the cheeks and segments of the axial lobe.

Length of an ordinary specimen seventeen millimeters; greatest width of thorax a little more than 8 mm.; length of head, 6 mm.; length of pygidium, 2 mm.

This species differs from all others described, in the elongate form of the head and in the proportions of the body.

ACIDASPIS, *Murchison.*

ACIDASPIS FIMBRIATA, *Hall.*

Plate 33, *Fig.* 11.

Acidaspis fimbriata, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 20. 1879.

Fragments of a species of ACIDASPIS occur upon the surfaces of some of the slabs which are mainly covered with Bryozoans.

The separated cheek pieces are distinguishable by the numerous straight lateral spines which give them a fimbriate appearance. As many as eleven of these lateral spines may be counted upon a single imperfect cheek. The border of the cheek is but slightly curved and the long posterior spine is nearly straight.

ILLÆNUS, *Dalman.*

ILLÆNUS ARMATUS, *Hall.*

Plate 34, *Figs.* 19, 20; *Plate* 33, *Fig.* 12.

Illænus armatus, HALL. 20th Rep. St. Cab. Nat. Hist., p. 320, pl. 22, figs. 1–3. 1867. Rev. edit., pp. 418, 433. [1870.]

Illænus Barriensis, (MURCH.) HALL. Trans. Alb. Inst., vol. iv, p. 227. Abstract, p. 33; May, 1863.

Illænus armatus? HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 189, pl. 32, figs. 19, 20. 1879.

The specimens of ILLÆNUS occurring in this locality are all fragmentary, and so imperfect that no satisfactory identification can be made. The form of the pygidium is like *I. armatus.* The head is more extended in front than in that species from Wisconsin, but this may be due in some degree to the compression which has flattened the specimens. One specimen retaining the movable cheek, with its posterior extension, has been observed, leaving little doubt as to the identity of the species.

ILLÆNUS (BUMASTUS) IOXUS, *Hall.*

Plate 38, *Figs.* 13, 14.

Illænus Ioxus, HALL. 20th Rep. St. Mus. Nat. Hist., p. 378, pl. 22, figs. 4–10. 1867. Revised edit., p. 420, pl. 22, figs. 4-10. [1870.]

Illænus (*Bumastus*) *Ioxus*, HALL. Trans. Alb. Inst., vol. x. Abstract, p. 20. 1879.

A large specimen of the caudal shield from the limestone at Waldron has all the proportions of this species, though of somewhat larger dimensions than is usual with the Wisconsin individuals. The specimen measures sixty millimeters in length, with a width of about 75 mm.

CERAURUS, *Green.*

CHEIRURUS, *Beyrich.*

CERAURUS NIAGARENSIS, *Hall.*

Plate 34, *Fig.* 16; *Plate* 33, *Fig.* 10.

Compare *Cheirurus insignis*, BEYRICH. Ub. Bohm. Tril., p. 12, fig. 1.

Compare *Cheirurus insignis*, BARRANDE. Syst. Sil. Cent. Boheme, p. 782, pl. 41.

Compare *Cheirurus insignis*, CORDA. Prod., p. 133, pl. 5, fig. 70.

Ceraurus insignis, Hall. Pal. N. Y., vol. ii, pp. 300, 306, pl. 67, figs. 9, 10. 1852.

Ceraurus insignis, Hall. 20th Rep. St. Cab. Nat. Hist., p. 335. 1867.

Ceraurus Niagarensis, Hall. 20th Rep. St. Cab. Nat. Hist., Rev. edit., p. 427, pl. 21, figs. 10, 11. 1870.

Sphærexochus Romingeri? Hall. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 32, fig. 16. (Erroneous reference.)

Ceraurus (*Cheirurus*) *Niagarensis*, Hall. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 189, pl. 32, fig. 16. 1879.

Ceraurus bimucronatus? (Murchison) Roemer. Silur. Fauna Westl. Tenn.; S. 80, T. V. fig. 19; not *Cheirurus bimucronatus*, Murchison. Siluria Foss. 64; fig. 4, pl. 3, fig. 5; and pl. 19, figs. 10, 11.

Compare *Cheirurus pauper*, Barrande. Syst. Sil. Cent. Boheme, p. 800, pl. 41, fig. 41.

Compare *Cheirurus obtusatus*, (Corda) Barrande. Syst. Sil. Cent. Boheme, p. 786, pl. 41, figs. 14–16.

This species, so far as known, is only represented by fragments of the cephalic shields found in New York, Wisconsin, Tennessee and Indiana, and nearly perfect specimens of the pygidia, also found at Waldron, Indiana. With the material now at hand, a more exact and satisfactory comparison can be made with various European species.

The only European species with a single obtuse node at the extremity of the pygidiam are *C. insignis* Beyrich, *C. pauper* Barr, *C. obtusatus* Corda; the other allied species have the extremity variously mucronate or emarginate. These species also all agree in the comparatively slender sharp spines on the lateral margins.

The pygidia found at Waldron may be described as follows:

Pygidium longitudinally subelliptical, very slightly convex, axis prominent in front, diminishing very rapidly in size and elevation toward the posterior end, composed of three prominent annulations, and a flat, rounded node extending beyond the margin, with two small circular depressions at the base near the third segment, probably indicating a rudimentary fourth segment. Lateral lobes composed of three pairs of segments, having a very short, deep furrow at the base of each segment; produced into three broad, flat, subtriangular curved spines, notched at the base on the anterior margin, extending outward and curving abruptly backward, concave to the axis. Surface granulose.

Surface of the glabella covered with small crateriform pustules. The fixed cheek is finely granulose, with small, irregular circular depressions.

From the above it will be seen that the separation first made in the revised edition of the 20th Rept. St. Cab., was necessary, and that it constitutes a distinct species.

NOTE ON THE GENUS DALMANITES AND ODONTOCEPHALUS.

CRYPHÆUS, *Green.* 1837.
ODONTOCEPHALUS, *Conrad.* 1840.
DALMANIA and DALMANITES, *Emmrich.* 1845.
ODONTOCHILE, *Corda.* 1847.*

The genus DALMANIA or DALMANITES of Emmrich has been generally adopted by European and American authors, overlooking the fact that Green, in 1837, proposed the name CRYPHÆUS, and Conrad, in 1840, proposed the name ODONTOCEPHALUS for forms now included under Emmrich's genus. The typical species of Conrad's genus was the *Asaphus selenurus* of Eaton, described in 1832.

In 1835, Green in the supplement to his *Monograph of the North American Trilobites*, described the head of a Trilobite under the name of *Calymene odontocephala*† from the denticulate character of the anterior margin of the buckler or cephalic shield. This species of Green was identified among the collections from the upper limestones of the Helderberg and Schoharie, and in 1840, Mr. Conrad discovered an entire specimen which had been collected at Auburn, N. Y. This specimen proved that the *Asaphus selenurus*, Eaton, of which only the caudal shield had been heretofore known, and *Calymene odontocephala* of Green, described from the head alone, were one and the same species, and he proposed the generic name of ODONTOCEPHALUS, and *Odontocephalus selenurus* as the typical species.‡

The name ODONTOCEPHALUS has, therefore, priority over DALMANIA by five years in time, and while, although naturalists would prefer to retain the use of the name Dalmania or Dalmanites, (the former being also used for a genus of dipterous insects), it becomes a question whether a just interpretation of the rule of priority would not require the adoption of the name ODONTOCEPHALUS. While aware of the fact that Mr. Conrad had thus described the *Asaphus selenurus* of Eaton, it has been customary to adopt the name Dalmania or Dalmanites, without considering the question of dates.

The distinguishing features of the genus CRYPHÆUS of Green (1837), are, according to its author, the fimbriate caudal shield, of which he remarks: "The second series of ribs, which proceed beyond the costal arches of the Cryphæus, we suppose will distinguish it from every other described genus." He remarks that "a very slight obliteration" of these parts "would give them all the characters of a Calymene"=Phacops.

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*The generic name CRYPHÆUS, proposed by Green in 1837, was already preoccupied for a genus of Coleoptera in 1833, and the name ODONTOCHILE had also been given to a genus of coleopterous insects in 1834.

†Cast No. 36 of Green's series Cast of Trilobites.

‡Third Annual Report Pal. Dept. N. Y. Geol. Survey, 1840.

In considering the question of generic identity, however, it should not be forgotten that the typical forms of the genus DALMANITES, which are similar to the Niagara and lower Helderberg species, have never shown the denticulated anterior border or fimbriated pygidium. The genus was originally characterized as having many annulations in the axis of the pygidium, but further investigation has included forms with few annulations. The ODONTOCEPHALUS, in its typical form, is characterized by the denticulate border, and a pygidium with few annulations in the axis. Similar characteristics mark the other allied species, so far as known.

Whatever may be the real value or importance of these structural modifications, it is interesting to find their manifestation coincident with the change or succession of the geological formations. The lowest forms, geologically, have simple phacopidean heads—(the posterior angles not produced) with pygidia, which are acute or subacute posteriorly and have numerous annulations in the axis. In the next phase these forms of the group have the posterior angles of the buckler prolonged into spiniform extensions, and the caudal extremity very acute or extended into a more or less elongate spine. A still further modification occurs in the next horizon where the posterior angles of the buckler are extremely prolonged, the caudal extremity extended into a long spine, and the anterior border of the head produced into a simple or bifurcate, or sometimes tridentate process. In the next geological period, we find the forms of this group having the posterior angles of the buckler either moderately or extremely prolonged, the caudal extremity truncate or emarginate (concave) and produced on each side posteriorly into a short spine (or sometimes with an accessory spine), on each side, and the extremities of the caudal ribs spiniferous. The anterior margin of the buckler is rounded or slightly produced and denticulate, either in the front alone or upon the entire border.

In the next stage the anterior margin of the buckler is rounded and simple, the posterior angles more or less prolonged into spiniform extensions, and the caudal extremity fimbriate with rounded or more or less flattened spiniform processes; of these there are five on each side of the axial extremity, which is likewise produced into a short flattened spine.

These extravagant forms of DALMANITES or ODONTOCEPHALUS, in the last two geological stages, are associated with the staid and almost unvarying PHACOPS which begins and ends its existence in the three latest named geological periods. * * *

For the present it is proposed to recognize the following species as DALMANITES, until it shall be determined whether the forms possessing the characters of the genus ODONTOCEPHALUS may be properly distinguishable as a separate group.

DALMANITES VIGILANS, *Hall.*

Plate 35, *Figs.* 1-4; *Plate* 33, *Fig.* 9.

Dalmanites vigilans, HALL. Rep. Prog. Geol. Surv. Wis., p. 57. 1861.
Dalmania vigilans, HALL. 20th Rep. St. Cab. Nat. Hist., p. 335, pl. 21, figs. 16–18. Rev. edit., p. 426.
Dalmania vigilans, HALL. Doc. edit. 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 33, figs. 1–4. 1876.
Dalmanites vigilans, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 193, pl. 3, figs. 1–4. 1879.

General form of body broadly ovate, greatest breadth across the posterior part of the cephalic shield.

Head convex, semi-elliptical, breadth about twice as great as the length (exclusive of the frontal projection); border extended in front into a triangular, sometimes truncate, process, the base of which is little less than one-half as wide as the width of the anterior portion of the glabella; in older individuals this projection becomes more obtuse and sometimes rounded; lateral borders broad, flattened, separated from the cheeks by a distinct groove, produced posteriorly into long, slender parallel spines, which do not extend beyond the general outline, and are continued as far as the extremities of the fifth thoracic segment. Glabella large, depressed-convex, widening in front to twice its width at the posterior margin, divided into lobes by three pairs of transverse furrows exclusive of the occipital furrow, which is distinct and continuous; the two posterior furrows distinct at the sides, but not extending entirely across the glabella except in a faint depression; the anterior. furrows deep, very distinct, situated a little anterior to the eyes, extending each about one-third across the glabella and giving to the frontal lobe a transversely elliptical outline; occipital ring narrow, ornamented in the middle by a single, short, sharp spine. Eyes very prominent, short reniform, containing about thirty-five vertical ranges of lenses, the middle ranges having nine each. Palpebral lobe depressed, giving great prominence to the rim of the eye. Cheeks small, prominent on the anterior portion, marked near the posterior border by a deep groove—the continuation of the occipital furrow; margin broad and flat.

Thorax with the axial lobe depressed convex, widest at the sixth segment, its greatest width more than two-thirds that of the lateral lobe. The articulations curve forward in the middle and at their junction with the lateral lobes, near the extremities they are bent suddenly backward, terminating in a sharp point. Articulations of the lateral lobes traversed by a deep longitudinal furrow extending from the middle lobe to the abrupt curve near their extremities.

Pygidium somewhat elongate-triangular, extended posteriorly into an acute spine; central lobe or axis marked by ten or twelve narrow annulations; the lateral lobes less prominently marked by ten flattened ribs, which are traversed by a deep furrow, and terminate in a narrow border; the two posterior pairs of ribs are directed obliquely backward.

Surface of the head, except the anterior and lateral border, covered with small irregular pustules, the border being finely granulose. The remainder of the body is granulose, with occasionally small pustules on the axial lobe of the thorax.

The Waldron specimens of this species were identified with specimens from Wisconsin, which formed the basis of the original description. The only important differences noticed are the lesser prolongation of the anterior process; the head is not so regularly semi-elliptical, but is more angular on the posterior side; the pygidium is somewhat more elongate and more acutely terminated. The species was originally described from specimens of the buckler and pygidia. In the recent collections from Waldron, there are several specimens retaining the thorax nearly entire, and from these the description of the species has been completed.

Compared with *D. verrucosus*, the head is proportionally narrower, the postero-lateral spines longer and less diverging; the pygidium is narrower and more elongate, and the surface is not so strongly covered with pustules. It somewhat resembles *D. limulurus* of the Niagara formation of New York, but differs in the proportionally larger glabella, the larger and more prominent eyes, and the extension of the anterior border.

Specimens of this form have proved comparatively rare in the collections thus far made at Waldron.

DALMANITES VERRUCOSUS, *Hall.*

Plate 35, *Figs.* 5-17; *Plate* 36, *Figs.* 13-15.

Dalmanites verrucosus, HALL. Trans. Alb. Inst., vol. iv, p. 218. Abstract p. 24; May, 1863.

Dalmanites verrucosus, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist., Mus. edit., p. 195, pl. 33, figs. 5-17; pl. 34, figs. 13-15. 1879.

General form elongate-ovate, the greatest breadth across the posterior part of the cephalic shield.

Head semi-circular, or, including the lateral spines which reach to the base of the fifth thoracic segment, broad crescentiform, the anterior margin produced in front of the glabella, forming a semi-circular projecting border about one seventh as wide as the greatest width of the glabella. Glabella convex, not very prominent, the greatest breadth about equal to the length forward of the occipital furrow. Anterior lobe transversely oval, about twice as wide as the posterior lobe, separated from the rest by a pair of rather deep, obliquely transverse furrows, which extend about four-fifths across the glabella. Posterior and middle furrows short, but deeply marked, not extending to the margins of the glabella. Occipital furrow narrow and shallow, more deeply marked in its continuation in the cheek furrows. Eyes large, prominent, having in their greatest elevation, nine or ten ranges of lenses, and thirty-five ranges in the other direction. Palpebral lobe depressed, giving great prominence to the rim of the eye. Lobes of the cheeks rather prominent: marginal rim broad, the lateral portions having a rounded, undefined ridge near the inner border.

Thorax with axial lobe depressed-convex, widest at the fourth and fifth segments, its greatest width not exceeding two-thirds that of the lateral lobe; the articulations curve forward in the middle and at their junction with the lateral lobes; articulations of the lateral lobes marked by a deep longitudinal furrow which commences at the juncture of the anterior margin with the axial lobe, and is directed backward, leaving the lower portion of the articulation about one-third of the whole width at the middle of the length, and again runs out on the upper margin, at the point where the articulation is bent abruptly backward.

Pygidium broadly triangular, the anterior lateral angles rounded and the lateral borders convex; axial lobe regularly tapering posteriorly, marked by thirteen annulations which gradually decrease in size posteriorly, and terminate in a slender spine about half as long as the caudal plate. The lateral lobe has ten articulations, eight of which are divided by a longitudinal furrow; the last two are simple, and all become obsolete just within the margin.

Surface of the head, except the anterior and lateral borders, covered with small, somewhat pointed pustules, the border having only a fine granulose texture. Occipital and axial rings of the thorax and pygidium each marked with seven small spiniform pustules, the central one the longest; those of the pygidium become closely crowded in the posterior portion; there are sometimes two or more additional smaller pustules on the stronger rings of the thorax.

Length of a medium-sized specimen (exclusive of the caudal spine) eighty millimeters; greatest width of the head somewhat more than 50 mm.; length of the head from the occipital ring, 15 mm.; greatest width of thorax 48 mm.; width of axial lobe 13 mm.; length of pygidium (exclusive of the spine) 28 mm.; greatest width of pygidium 48 mm. Some of the large cephalic shields have a width of from 80 to 100 mm.

The heads of this species, in a tolerably good state of preservation, are very common; the remainder of the body being mostly found in a fragmentary condition.

DALMANITES BICORNIS, *Hall.*

Plate 35, *Fig.* 18.

Dalmanites bicornis, HALL. Doc. edit., 28th Rep. St. Mus. Nat. Hist. Explanation of pl. 33, fig. 18. 1876.

Dalmanites bicornis, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 196, pl. 33, fig. 18. 1879.

This species is indicated from the occurrence of an incomplete border of the buckler, which preserves a strong bifurcatory anterior process—a feature sufficiently characteristic to distinguish it from any trilobite of the Niagara formation yet known to us. The form bears much general resemblance to *D. nasutus* of the Lower Helderberg formation, which has a much larger bifurcating anterior process, and in which the anterior lobe of the glabella is projected forward beyond the line of general contour of the cephalic shield.

LICHAS, *Dalman*.

LICHAS BREVICEPS, *Hall*.

Plate 36, *Figs.* 1-7.

Lichas breviceps, HALL. Trans. Alb. Inst.; vol. iv, p. 222. Abstract, p. 28; May, 1863.

Lichas breviceps, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 197, pl. 34, figs. 1-7. 1879.

Not *Lichas breviceps*? HALL. 20th Rep. St. Cab. Nat. Hist., pp. 334, 337, pl. 21, figs. 12-14. Rev. edit., p. 424. (*Lichas emarginatus*.)

Head broad and short, somewhat crescentiform, projecting in front and prominent in the middle, the length about one-third as great as the width, posterior angles directed backward in short obtuse spines. Glabella very convex, wider than long, rounded in front, distinctly divided into three lobes, two lateral and one central, the central lobe narrower behind and rapidly expanding in front, the lateral lobes reniform and about as wide as the posterior part of the central or anterior lobe, commencing forward of the eye and reaching to the occipital furrow. Eyes very prominent, reniform, very convex on the visual surface, having the appearance of the eyes in ILLÆNUS. Anterior border of the head very narrow in front of the glabella, being only a rounded rim. Cheeks flat or slightly concave, with a prominently rounded ridge just beneath the eye. Occipital ring prominent; furrow deep, becoming very faint in its extension into the cheek furrows. Surface of the head marked by fine scabrous pustules.

A portion of the thorax connected with a pygidium preserves the remains of ten articulations, in one of the lateral lobes and on a part of the axial lobe. The axial lobe is wider in the middle than at its junction with the head, and from the seventh articulation gradually tapers to the pygidium. The lateral lobe is a little more than two-thirds as wide as the axial lobe in its greatest width; the articulations are somewhat abruptly turned backward toward their extremities, which are closely arranged and in contact, except the last one, between which and the first segment of the pygidium is a narrow free space.

The separated pygidia present the following characters: General form semi-elliptical, a little rounded on the the anterior border: axial lobe broad and strong, very prominent in the anterior part, rapidly narrowing and becoming low in the middle and again widening posteriorly; its width at the anterior margin being about one-third as great as the whole width of the tail; a single anterior annulation. Lateral lobe with three segments on each side, and each marked by a broad, shallow, longitudinal furrow; at the posterior side of the two anterior ones, the margin of the shield is slightly indented, below this it is entire, with a regularly curved outline; the two anterior segments are curved a little backward and their extremities free, while the third one is curved first outward and then downward, uniting with the depressed axial lobe. The enfolding of the crust on the lower side extends upward about three-fifths of the length of the tail, and is strongly but distantly lamellose-striate.

Exterior surface marked by pustules of moderate size, and a few short hollow spines.

It resembles *L.* (*Platynotus*) *Trentonensis* as recognized in the blue shales of the Hudson river group of Cincinnati, in the prominent eyes; but the head is much shorter in proportion to its width, and the tail is broader and more nearly straight on the anterior margin.

LICHAS BOLTONI, (*Bigsby*) var. OCCIDENTALIS, *Hall.*

Plate 26, *Figs.* 8–11 *and* 12?

Lichas Boltoni, var. *occidentalis*, HALL. Trans. Alb. Inst., vol. iv, p. 223. Abstract, p. 29; May, 1863.

Lichas Boltoni, var. *occidentalis*, HALL. 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 198, pl. 34, figs. 8-11.

Lichas, ——— *sp?* 28th Rep. N. Y. St. Mus. Nat. Hist.; Mus. edit., p. 193, pl. 34, fig. 12. 1879.

For citations, see Pal. N. Y., vol. ii, p, 311. 1852.

Body and head depressed, axis convex or rounded, lateral lobes often entirely flat; buckler lunate, extended in front into a kind of proboscis. Glabella convex, broad and prominent in front, separated by a groove from the frontal extension, narrowed posteriorly to the middle, and separated by a distinct furrow from a large lateral lobe on each side, the base expanded to nearly the same width as the front, and reaching to the base of the eye-tubercles. Lateral lobes of the glabella ovoid, having their longitudinal axis directed obliquely forward. Eye-tubercles auriform, broader at the base. Transverse furrow broad and well defined, extending nearly to the posterior angles of the cephalic shield. Facial suture coming to the base of the buckler about half way between the eye and the posterior angle. Thorax composed of eleven articulations. Axis convex, gradually tapering to the posterior extremity. Lateral lobes with the articulations flat, falcate, a distinct broad groove extending the entire length and terminating in the acute extremities of the segments.

Pygidium laciniate; axis marked by two narrow articulations above, and a third posterior one which is prominent and very convex in the middle, from whence it abruptly slopes downward, becoming confluent with the expanded border; lateral lobes composed of three articulations which are much expanded in the middle, but contract to acute points below forming the laciniate margin.

Entire surface scabrous, having the acute pustulose points directed backwards.

The hypostoma is attached directly below the front of the glabella. It is broadly rounded in front, and notched or obtusely bifurcate behind, marked by a large convex area in the upper portion, with two small elevated nodes near the posterior end, one each side of the centre of the entire hypostoma.

This form is known almost entirely from the pygidia, most of the specimens being in an imperfect condition. The middle lobe of the pygidium is short and the articulations are more prolonged than in the usual forms of *L. Boltoni* in the Niagara shales of New York. This character, however, is subject to some variation, even among collections from the same locality, as may be seen by comparing the figure on plate 69, with 1g on plate 70 of Vol. II, Pal. N. Y.

A specimen of the right cheek indicates that the head was longer and more curved on the posterior margin.

In some of the New York specimens, the anterior border in front of the glabella is produced into a broad subnasute extension, and a single fragment, of what appears to be a similar but more extreme anterior prolongation of the head, has been found at Waldron (figure 12 of plate 36.) Should this be proved to belong to the form represented in figures 8, 9 and 10, the difference between the New York and western specimens would be still more marked. The individuals reached a large size, as is shown by a fragment of the thoracic segments, having a width of nearly one hundred and twenty millimeters.

FOSSILS OF THE INDIANA ROCKS.

(NO. 2.)

By C. A. WHITE, M. D., Washington, D. C.

INTRODUCTORY REMARKS.

In compliance with the request of Professor Collett, who desires to have his reports, as far as practicable, addressed to the general reader, and in accordance with the course pursued in the last report, I precede the more formal descriptions of the fossils, which have been selected for that purpose, by some elementary remarks concerning them, and by some general remarks concerning the material that is here described and illustrated.

It would be much more satisfactory to the writer, as well as more instructive to the reader, if at least the principal part of the known fossils of each formation in the State could be presented and illustrated at once. This would involve a large amount of work and the publication of several volumes, but in such a case the relations of the different kinds to each other and to living forms, and the relations of those of each of the formations to those of the others could be readily pointed out, and as readily understood.

The lack of sufficient funds at the disposal of the survey, however, makes it necessary to do this work, or a portion of it, by piece-meal, and in selecting the material for description and illustration we are at present obliged to be governed by what we find practicable to do, and to select such material as is at present available and suitable to be used. This explanation is deemed necessary because of the obvious lack of systematic completeness in the character and extent of the paleontological material which is presented in these reports. It is not, however, by any means to be understood, that this material or any part of it, is unimportant. On the contrary, every form here presented is illustrative of some important fact, and each one conveys information of some characteristic of the formation from which it has been obtained.

Last year several different persons gave the use of fossils from their private collections for description and illustration, and this year others do the same, but a part of them are from the State collections. Dr. Moses N. Elrod, of Hartsville, Indiana, has sent some interesting collections from the Niagara group of that place, a part of which are figured and described in this article. Mr. William Gibson, of Newport, Indiana, also sends some interesting coal measure and other fossils.

The collections of both these gentlemen contain species that are new to science, as will be seen by reference to the descriptions on following pages.

Although several of the species herein described are new, and therefore of some especial interest, they are no more instructive than the greater part of them, which have become more or less well known. Some of the species here illustrated have also been figured in the geological reports of other States, but quite a number of them are here figured for the first time, although a part of these were originally described without illustrations. Plates 37 to 43 inclusive are illustrations of various Indiana fossils, from pen drawings by Dr. J. C. McConnell, and are reproduced by the photo-engraving process, as all of them were last year. But all the illustrations on plates 44 to 55, inclusive, are those of fossil corals which occur in the various great geological formations parts of which occupy different portions of the State of Indiana. These figures were all engraved by the late John W. Van Cleve, Esq., of Dayton, Ohio, to accompany a work on the fossil corals which he had prepared for publication as early as 1847, but delaying its publication from time to time, for the purpose of revising it, the work was stopped by his death, which occurred in 1858, and it was consequently never published. The engraved tablets of the twelve plates mentioned have been furnished to the survey by Dr. Julius S. Taylor, a life-long friend of the deceased author.

It is unfortunate that Mr. Van Cleve did not publish his work at the time he prepared it, as it would for that time have been a very complete one, and also almost the only work on the fossil corals of North America; for it was prepared before the great and standard works of Edwards & Haime, Hall, Billings, Nicholson and others had appeared, and when that of Dana had only just been published. The consequence is that while most of his species were new to science when he did his work, almost all, if not all of them, have since been published by various authors under different names from those which he had applied. The latter being the first published names, the rules of naturalists require them to be used in preference to all others, and we can only regret that the author of that work did not live to reap the fruit of his labors, and give our testimony to the zeal and ability which the unpublished work of the dead naturalist shows that he possessed.*

Although Mr. Van Cleve obtained most of his collections from the adjoining State of Ohio they are from geological formations which also occur in different parts of Indiana; and the illustrations which have been selected for this report are those of species which are either well known in those formations, or which are likely to be found in them within the limits of the State.

Referring to these figures from a rigidly scientific and artistic point of view, it is but just to say that while they betray the most painstaking care, and extensive knowledge of the subject on the part of their author, the expert student of fossil corals of the present day will detect certain inaccuracies of detail in some of them; and in others a close resemblance of outward form with certain of the figures in the great work of Goldfuss. But as a whole, compared with the work that had been published at the time these figures were prepared, and with a large proportion of the illustrations of fossil corals that have been published since, they are really superior, and they will be very valuable to the numerous students of geology in the schools of the State in assisting them to identify the fossil corals of the various formations.

In the brief description of each of the species of these fossil corals which I have given on the following pages, I have classified them according to their structural relations, and also according to the formations which they help to characterize; but in the arrangement of the figures upon the plates, I have not followed the order of arrangement which is adopted for the first seven plates, but I have considered only the convenient filling up of the spaces. Consequently species not closely related to each other, and also species from different geological formations will be found on the same plate. But these corals will be further discussed in some general remarks which are to follow, and full descriptions of the species, with references, will also be given.

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*See a letter on page 401, from Dr. Julius S. Taylor, giving some account of the life of Mr. Van Cleve.

In last year's report I gave some general account of the order and distribution of the different geological formations in the State, and showed that each of them is characterized by its own peculiar fossils, a few species from each of which were illustrated and described in that report. Referring to the remarks there made, it is only necessary now to say that of the few fossils which have been selected for illustration in this report, those represented on plates 37 and 38, are from the Upper Silurian; those on 39, 40 and 41 are from the Subcarboniferous, and those on 42 and 43 are from the coal measures. The fossil corals represented on plates 44 to 55, inclusive, are from the Lower Silurian, Upper Silurian, Devonian and Carboniferous formations.

The two species which are described on following pages, under the names respectively of *Gyroceras elrodi* and *Orthoceras annulatum*, and illustrated on plates 37 and 38, are both fossil shells which are related to the *Nautilus* of existing seas, the latter being a shell which is as well known in literature as it is in science. In the case of the *Nautilus* the shell is closely coiled upon itself so that its whorls are in close contact with each other; but the whorls of the *Gyroceras* are a little separated from each other, as shown in the figure upon plate 37, while the shell still preserves the spiral form as perfectly as that of *Nautilus*.

There are still other genera of this class of shells in which the coil is much more open than that of *Gyroceras*, and some are even only gently curved, while in the case of *Orthoceras* the shell is straight or sometimes very slightly bent. If, then, we imagine the shell of a *Nautilus* or *Gyroceras* to be uncoiled and drawn out until it is nearly or quite straight, we shall have an

Orthoceras; the other characteristics of all these shells being practically the same. In other words, *Nautilus* is a closely, and *Gyroceras* a loosely coiled shell, and *Orthoceras* a straight one; all three of them being what are known as chambered shells, of which there are many other generic kinds found in a fossil condition in the rocks of different geological ages. That is, these shells are divided into chambers by having partitions of shell-substance extending transversely across the cavity, at somewhat regular intervals through a considerable part of its length. As the animal grew in size it increased the size of the shell also by additions to its border; and as the portion of the shell which was previously occupied by the animal became too small for its accommodation with its increased size, it moved its body forward and built a shelly portion behind it; separating itself from the abandoned chamber, and confining itself to the "front room" of its dwelling. This process was repeated again and again until many unoccupied chambers were formed, the animal always occupying only the outer chamber, which was always the largest one.

The shell which I have named *Patella levettei*, and which is illustrated by figures 4 and 5 on plate 39, belongs to the limpet family, living representatives of which are common upon our sea coasts. The two species of shell called *Bellerophon*, which are represented by figures 5, 6 and 7 on plate 40, and figures 4, 5 and 6 on plate 41 belong to a genus which, although quite common in former geological times, is now entirely extinct; and its nearest living relations are among the rarest of living marine shells. The shell represented by figures 7 and 8 on plate 42 has living relatives among the sea snails; and shells much like that which is represented by figures 9 and 10 on plate 42 are not uncommon in existing seas. It should be borne in mind, however, that every object of every kind that is illustrated and described in this article; and every one, of organic origin, which is to be obtained from any of the geological formations of Indiana, have long since become extinct. We know what the character of those objects was when they were alive, from their greater or less similarity to living forms, but those species have long since ceased to exist; and the differences between some of them and living forms is very great.

The shells represented by figures 1 to 6 inclusive on plate 42, and figures 6, 7 and 8 on plate 39, belong to two different species and genera of the class of bivalve shells called Brachiopoda, the general characteristics of which were explained in the report for last year.

Figure 2, on plate 41, represents a form which has living representatives among the sea urchins of the present seas, but none are now living which are very closely related to it. A considerable proportion of the figures which have been prepared for this report are those of Crinoids of different kinds. The general character of these interesting forms was explained in the report for last year, and it is, therefore, not necessary to repeat it here. None of the fossil forms that are obtained from any strata are more interesting and beautiful than these, and the strata of Indiana have furnished a great variety, and large numbers of them. Five species of Crinoids are figured on the plates accompanying this article, one of which has never before been described. They are illustrated by figures 1, 2 and 3, plate 39; 1, 2, 3 and 4, plate 40, and figure 1, of plate 41.

Figure 7, on plate 41, represents the spiral axis of one of the very many forms that belong to the class Bryozoa, or Polyzoa, both names of the class being used by different authors. Although in form they resemble mosses, lichens and other plants, they are true animal bodies, and the parts that are found in the fossil condition consist of the stony or shell-like skeletons, each one of which has been produced by hundreds or even thousands of minute animals, all grown together in a manner similar to that by which coral is produced by coral-polyps; but the structure of the minute animal which constructs the *Bryozoum* is more nearly like that of the mollusks than the polyps. The separate animals of the Bryozoa are very minute, many of them being too small to be distinguished satisfactorily by the naked eye. The figure on plate 41, shows upon the edge of the spiral portion fine crenulations, which are, in fact, portions of the inner border of a continuous spiral expansion or thin frond, from one to several inches wide, which grew out from and around the axis, giving the whole the appearance of an erect spiral plant. This thin frond-like expansion was filled with small holes passing through it like those of a fine net, the size of which holes is indicated by the crenulations before referred to. Upon the edges or sides of the threads or dissepiments which constituted the net-like frond there are five pores to be seen by the aid of a lens, and each of these pores was the seat of a separate animal. Although each one of these minute animals was complete in its own individual organization, it was, nevertheless, connected with every other one of its kind in all the colony which formed the Bryozoan mass, by a continuation and confluence of its living soft parts, which enveloped all the hard parts, including the strong axis, which was fixed by the lower end to the bottom of the water in which it grew. The bodies which we now designate as fossil Bryozoa are therefore really the compound skeletons of colonies of minute animals. In some cases the Bryozoa constituted a thin encrusting mass upon other objects, such as shells or corals, but they very often imitated more or less completely certain vegetable forms, as do their representatives which are now found living in all seas. So close indeed is this resemblance to vegetable forms that they are often mistaken for sea weeds by those who see them upon the sea shore.

Figures 8 and 9 upon plate 41, represent a small fossil sponge. The common sponge is so well known in every household that the word has come to be used to indicate something soft, porous and pliable; and yet only a part of the true sponges of the present seas have that character; and the fossil sponges were quite as variable in their characteristics as the living ones are. Sponges were long believed to belong to the vegetable kingdom, and to be related to the sea weeds; but they are now regarded as properly of animal origin, belonging to the Protozoa, or lowest forms of animal life. The sponge with which we are most familiar, like all others, is really the skeletal support of the gelatinous envelope which is in fact the compound animal substance that forms the sponge, as an ordinary animal forms its own skeleton; and which as completely covers it in the living state, as the skeleton of any animal is covered. The animal substance of the sponge is rotted away in the process of preparing the sponge for the market. The substance of a common sponge much resembles that of horn, but other sponges, both fossil and living, are composed of other substances. Some of them are of stony character, and the beautiful "glass sponge," which has within a few years become somewhat common in museums and cabinets, is made up of a delicate network of fibers which have the composition of flint.

The sponge which is represented on plate 41 was probably of a calcareous, stony character when living, but it is now changed to a silicious substance.

The large figure 1, on plate 43, is that of the imprint on shaley sandstone of a sea-weed-like plant, from the coalmeasure strata of Fountain county, Indiana; and figures 2 and 3 of the same plate are impressions in shale of fragments of two species of land plants from the same formation. These two last named plants had a slender stem, with whorls of small leaflets placed at intervals along its entire length.

All the figures on plates 44 to 55, inclusive, are those of fossil corals, with the exception of the species represented by figures 4 and 5 on plate 53, which is regarded as being related to the sponges; and that represented by figure 3 on plate 55, which belongs to the Bryozoa, the general characteristics of both of which have just been described.

Fossil corals, like their living representatives in the present seas, are of great variety of form and structure. Some of them are much like the living kinds, but many of them possess interesting and important differences. Some of them, for example those that are represented on plate 45 and parts of plates 51 and 55, are in shape so much like the horns of some animal, that those who are unacquianted with their character often call them "petrified horns." Such corals were each formed by one large polyp, and the coral constituted its internal stony skeleton, for the coral was wholly enveloped in the soft tissues of the polyp which formed it, as all corals are.

The greater part of all corals, however, are compound. That is, they are formed by an aggregated mass of polyps, all grown together more or less compactly, which originated from a common parent polyp by a process of budding similar to the budding of plants, or of splitting spontaneously into two or more nearly separate parts, which all became separate polyps with growth. Each polyp is a separately organized individual, but all of those which form a compound mass or corallum are connected together by living tissue, the mass of coral which they form, being the compound skeleton for the whole colony.

In the case of some of these compound fossil corals, as seen represented upon our plates, the parts, or corallites, each of which was formed by an individual polyp, are not in close contact with each other; in which case they resemble a mass of roots of some plant; such for example as those represented by figure 3 of plate 47, figure 1 of plate 48, figures 1 and 3 of plate 49 and figure 1 of plate 51. In other cases the corallites are a little closer together, and yet not in close contact, as those of figure 1 of plate 50. In many cases the corallites are in such close contact that they necessarily assume a many sided form like the cells in honeycomb. Indeed so closely do some of these coral masses resemble that object that the people often speak of them as "petrified honeycomb;" and the scientific name of one genus of these corals *Favosites* is derived from the Latin word signifying the same thing. The cells or corallites of these honeycomb-like corals varied greatly in size, many of them being even much larger than those of figure 2, plate 49, and figure 3, plate 52. Others are much smaller, as for example those of plates 44 and 54; and still others are minute, almost as small as hairs, such for example as that which is represented by figure 2 on plate 48. In some cases the corallites were in the form of tubes more or less completely filled up by small transverse and radiating partitions, the latter often not well developed. Specimens showing the surface of such corals with the open mouths of the corallites are represented by figures 1 and 2 of plate 44, figures 4 to 7 of plate 46, figure 1 of plate 52, and others. Those represented on plate 46 are joined together by only two sides of each corallite, which gives their open mouths the appearance of a chain when viewed from above; and this coral has therefore received the name of "chain coral."

These hints may serve to interest the beginner in the study of fossil corals, but to gain any real knowledge of these interesting forms one must give long and patient study to the objects themselves.

DESCRIPTIONS OF FOSSILS.

The fossils which are described on following pages and figured on plates 37 to 43 inclusive, are in large part of species which have been described by different authors, and at various times; but a part of these species have never before been figured. Four of the species are new, and are here described and figured for the first time.

All the figures on plates 44 to 55 inclusive, were engraved many years ago by the late J. W. Van Cleve, as has already been stated. The species represented by these figures have been identified by aid of the descriptions and figures which the various authors have published who have written upon American fossil corals; and the descriptions which are here given of these species have been mainly copied or derived from this source. In short, I claim no authorship in this portion of the work, and I have only attempted to identify the species which are illustrated by the figures, and to make them available to those who may desire to study the fossil corals of the State.

UPPER SILURIAN.

MOLLUSCA.

CEPHALOPODA.

Genus GYROCERAS, *Meyer.*

GYROCERAS ELRODI (sp. nov.)

Plate 37, *Fig.* 1, *and Plate* 38, *Figs.* 2, 3 *and* 4.

Shell moderately large, composed of about two and half whorls, all separate except perhaps the first one, which is very small, and mostly obscured in our examples by the inbedding rock; the transverse section of the whorls having a nearly regular outline, except that the peripheral side is a little flattened, or its convexity is somewhat less than that of the umbilical side; the long diameter of the whorls lies in the plane of the coil, and increases in proportion to the short diameter with the growth of the shell, the small inner volution being nearly circular in cross section, while the longer diameter of the outer portion is about one-third greater than the shorter. Septa comparatively few, or not crowded, moderately concave, plain; the sutures extending nearly straight across the peripheral portion, and across the sides with gentle sinuosity, which is scarcely apparent in the case of the inner septa, but upon the outer ones the sinuosity is somewhat distinctly marked. Body chamber large. constituting more than half the bulk of the shell. Siphuncle rather small, placed subcentrally, or a little nearer to the umbilical than to the peripheral side.

The coil of the shell, in the case of the example figured, seems to be slightly irregular, the separation of the whorls being a little greater in some parts than in others; and the outer portion of the body chamber, while not losing the primary curved character of the shell, diverges at its outer portion considerably away from the more regular curve of the inner portion. This feature is an apparent approach to the chief distinguishing characteristic of *Lituites*, but it is evident that in our shell it was a comparatively slight feature and confined to the outer portion only of the body chamber, and that this slight divergence of the coil never involved any of the septate portion.

The surface is marked by numerous revolving lines which are apparently distributed over the whole surface; and these are crossed by similar transverse lines, which evidently correspond with the lines of increase which were formed upon the borders of the aperture of the growing shell. The latter lines extend across the whorls from the umbilical to the peripheral side, in an outward and backward direction, and with a curve, the convexity of which is forward.

The distinct separation of the whorls in this shell together with its other characteristics, distinguish it as a true *Gyroceras*; and its specific characters are such as to separate it clearly from every other published form that it is likely to be confounded with upon casual examination. It bears some remblance to both *G. ohioense* and *G. inelegans*, Meek, from the Devonian strata of Ohio. From the former, it differs in the absence of any transverse ridges, and from both in the distinct separateness of the whorls and their less rapid increase in size.

Diameter of the coil, measured from the outer side of the aperture to the opposite periphery, 210 millimeters.

Position and locality. Niagara Group; limestone layers beneath the shales, Hartsville, Indiana, where it was collected by Dr. Moses N. Elrod, in whose honor the specific name is given.

Genus, ORTHOCERAS, *Breynius*.

ORTHOCEROS ANNULATUM, *Sowerby*.

Plate 38, *Fig.* 1.

Orthoceras annulatum, SOWERBY, 1818. Mineral Conchology, Tab. 133.
Orthoceras annulatum, HALL, 1868. 20th Rep. Reg. Univ., N. York, p. 351.
Orthoceras laphami, MCCHESNEY, 1860. New Pal. Fossils, p. 91.
Orthoceras nodocostatum, MCCHESNEY, 1860. New Pal. Fossils, p. 94.
Orthoceras nodocostatum, MCCHESNEY, 1867. Tran. Chi. Acad. Sci., vol. i, p. 53, pl. 9, fig. 5.

The collections contain a single, somewhat imperfect example of an annulated *Orthoceras*, which seems to possess the outward characteristics of the species which has been found in the Upper Silurian rocks of various parts of the United States, and which has been generally referred to *O. annulatum*, Sowerby. The shell is conspicuously marked by strongly raised annulations, and when perfect it was long and slender, or very gently tapering. In the case of our example the surface, both upon, and between the annulations is seen to be marked by numerous slightly raised longitudinal lines, which are quite distinct when viewed by cross-light. These longitudinal lines are crossed by numerous somewhat regular, finely undulating lamellose concentric striæ, which, although not so distinct as the longitudinal lines, together with them give the surface a rugose cancellated appearance. This surface characteristic, together with the strong annulations, is correctly shown in the figure on plate 38, except that the artist has given it a little stronger appearance than it naturally has in ordinary light. The septa of *O. annulatum* are described as being strongly concave, and the siphuncle small. Our example agrees with this description in regard to the septa, but the character of the siphuncle is not clearly made out. There is, however, a comparatively large cylindrical body, occupying nearly the position of a siphuncle, and which may really be of that character; but it resembles a small, slender, smooth *Orthoceras* which has reached that position by accident. The end of this body is represented at the lower end of the figure.

Position and locality. This specimen, like those of the preceding species, was collected by Dr. Moses N. Elrod from the limestone strata of the Niagara Group, beneath the Niagara shales, at Hartsville, Indiana.

SUBCARBONIFEROUS.

GASTEROPODA.

Genus PATELLA, *Linnæus*.

PATELLA LEVETTEI (sp. nov.)

Plate 39, *Figs*. 4, 5.

Shell suboval in marginal outline, broader in front than behind; both anterior and posterior margins regularly rounded, but the latter margin more narrowly rounded than the former; lateral margins very gently convex and regularly rounded to both the posterior and anterior margins; apex placed at about two-fifths the full length of the shell from the front, turned strongly forward; the sides and front sloping at a nearly uniform angle from the apex to the margins, the slope being gently convex; the posterior slope longer and more strongly convex than either the sides or front. Surface marked with concentric lines and somewhat numerous stronger marks of growth, but otherwise plain.

Length, 26 millimeters; breadth, 14 mm; height, 9 mm.

A single example of this shell was obtained by myself at Spergen Hill. It seems to possess all the characteristics of true *Patella*, although it comes from paleozoic strata, and the genus to which it is referred is a common one among living mollusca. This shell bears some resemblance to a *Crania*, but it is much more elongate in marginal outline than any known species of that genus, and it is also much more elevated. The specific name is given in honor of Dr. G. M. Levette, formerly of the Geological Survey of Indiana.

Position and locality. Warsaw Division of the St. Louis group of the Subcarboniferous series, at Spergen Hill, Washington county, Indiana.

Genus BELLEROPHON, *Montfort*.

BELLEROPHON SUBLÆVIS, *Hall*.

Plate 40, *Figs*. 5, 6 *and* 7.

Bellerophon sublævis, HALL. 1858. Trans. Albany Inst., vol. iv, p. 32.

Shell subglobose, having a compact, somewhat inflated aspect; aperture expanded a little at the sides, but not in front, its lateral diameter greater than the median, having an arcuate appearance when viewed in front, because of the projection into it of the rounded dorsum of the preceding whorl: umbilicus none, the umbilical spaces being covered by the thickened and expanded lateral edges of the lip; dorsal keel narrow, inconspicuous; lip thin in front, thickened and reflected at the sides; the front margin rounded upon each side into a deep median notch. Surface nearly smooth, but marked by faint lines and undulations of growth, the direction of which agrees with the borders of the lip.

Length, 19 millimeters; extreme breadth of aperture, 18 mm.

Position and locality. This species was first described from the Warsaw division, St. Louis group, of the Subcarboniferous series at Spergen Hill, and Bloomington, Indiana, but the specimens here described come from strata of the same formation at Ellettsville, Monroe county, Indiana.

BELLEROPHON GIBSONI (sp. nov.)

Plate 41, *Figs.* 4, 5 *and* 6.

Shell very large for a species of this genus; whorls gradually increasing in size, broadly rounded upon the outer side, especially of the outer portion of the last one; aperture large, expanding by reflexion of the lip at the sides, but apparently not so expanding in front.

The larger examples, when perfect, had a length of at least 65 millimeters, and a breadth of aperture of 50 mm.

This is one of the largest species of *Bellerophon* that is yet known in North American rocks, but unfortunately the condition of the only specimens of it which have yet been obtained will not admit of a full description, they being in fact only natural casts of the interior of the shell. The space between the whorls as shown in figure 5 is without doubt an indication of the thickness of the test, since the whorls were, of course, in contact. This indicates that the test was strong and massive. No indication has been obtained as to the character of the surface markings of the shell, but that of the cast is, of course, smooth. Ordinarily the description and naming of a species ought not to be attempted from such imperfect material as these examples afford; but the few characteristics which are here described and illustrated on plate 41, together with its remarkably large size, will make the identification of the species an easy matter.

Position and locality. St. Louis group of the Subcarboniferous limestone series; Greencastle, Putnam county, Indiana. The specific name is given in honor of Mr. Wm. Gibson, of Newport, Indiana, who has furnished to the survey many interesting fossils for study.

BRACHIOPODA.

Genus TEREBRATULA, *Llhwyd.*

TEREBRATULA FORMOSA, *Hall.*

Plate 39, *Figs.* 6, 7 *and* 8.

Terebratula formosa, HALL. 1858. Trans. Albany Inst., vol. iv, p. 6.

Shell elongate, subovate in marginal outline; ventral valve strongly convex from beak to front, beak prominent and strongly curved; dorsal valve less convex than the ventral; the borders of the two valves meeting at the sides and in front somewhat acutely; the front margin usually somewhat truncated, but there is no proper sinus in either valve. Surface smooth, or marked only by the ordinary lines of growth.

Length of the largest example in the collection, 25 millimeters; breadth of the same, 16 mm.

The examples from which the foregoing descriptions are drawn are considerably larger than those which were originally described by Prof. Hall, and yet they seem to be specifically identical with them, and were found at the same locality. Still larger examples were found associated with these, which are also believed to be of the same species.

Position and locality. Warsaw division of the Subcarboniferous series, Spergen Hill, Washington county, Indiana.

BRYOZOA.

Genus ARCHIMEDES, *Lesueur.*

ARCHIMEDES LAXA, *Hall.*

Plate 41, *Fig.* 7.

Archimedes swalloviana, HALL. 1857. Proc. Am. Asso. Adv. Sci., vol. x., part 2, p. 178.

The collections contain some examples of the axes of a species of *Archimedes*, one of which is represented by figure 7, plate 41, and which appears to agree with Prof. Hall's description of *A. swalloviana.* It is very doubtful whether the axes alone of any *Archimedes* possesses distinguishing characteristics which ought to be relied upon for the determination of species. At least it seems certain that considerable differences exist in the axes of different examples of the same species; and also that the character and arrangement of the fenestrules and pores in some cases show specific differences which the axes alone do not reveal. Therefore as these axes, which are contained in this collection, are not accompanied by any portions of the frond, no specific description is here attempted.

RADIATA.

ECHINODERMATA.

Genus LEPIDESTHES, *Meek & Worthen.*

LEPIDESTHES COLLETTI, *White.*

Plate 41, *Figs.* 2 *and* 3.

Lepidesthes colletti, WHITE. 1878. Proc. Acad. Nat. Sci. Philad., p. 33.
Lepidesthes colletti, WHITE. 1880. An. Rep. U. S. Geol. Sur. Ter. for 1878. Part i., p. 163, pl. 40, fig. 2.

General form apparently ovate. Interambulacral areas very narrow, linear, slightly convex from side to side, composed of four or five rows of small pieces, which rows do not apparently decrease in number, except perhaps near each extremity. Ambulacral areas broad, partaking of the convexity of the body, lance-oval in outline, and five or six times as broad as the interambulacral areas are. Ambulacral areas made up of very numerous small rhombic pieces, the transverse diameter of which is a little greater than the vertical; their lateral angles moderately acute, and interlocking so that they appear to be arranged in oblique rows; size of the pieces nearly uniform throughout the field, except that they all become a little smaller near both the upper and lower extremities. The number of vertical rows of pieces in each field is apparently 18 or 20. Each ambulacral piece has two distinct round pores, near each other, and near the upper angle of the piece, but they are sometimes obscured by the overlapping of adjacent pieces. Surface granules small, more distinct upon the interambulacral than upon the ambulacral pieces.

Two examples of this species have been discovered, both of which are crushed and otherwise in a much damaged condition. The original height of the larger one was about 45 millimeters, and its transverse diameter apparently considerably less.

The crushed condition of the specimen causes some doubt as to the true number of longitudinal rows of interambulacral pieces, but they evidently do not exceed five. There seems to be only four rows to each area, one row of comparatively large pieces, with two rows of smaller ones on the right-hand side of it, and one similar row on the left. This want of bilateral symmetry in the visible rows of pieces suggests the possibility, that one row of smaller pieces on the left-hand side of the row of larger ones, has been forced beneath the others and out of sight, by pressure, but a careful examination fails to reveal any evidence of it.

This species is clearly distinguished from *L. coreyi*, MEEK & WORTHEN, the only other known species of the genus, by the very much narrower interambulacral areas, the different and varying proportions of the pieces which compose those areas as well as some other important but less conspicuous differences. The specific name is given in honor of Prof. John Collett.

Position and locality. Keokuk division of the subcarboniferous series, Salem, Washington county, Indiana.

Genus AGARICOCRINUS, *Troost.*

AGARICOCRINUS SPRINGERI (sp. nov.)

Plate 40, *Figs.* 2, 3 *and* 4.

Body of medium size, the portion below the arms shallow, convex; base truncate but not depressed; column moderately large, the cicatrix for its attachment concave, the last joint almost completely covering the basal pieces; first radial pieces wider than long, and they are the largest of the radial series; second radial pieces very short, more than twice as broad as long; third radial pieces triangular, and so small, in some of the rays at least, that the first piece of the secondary radial or brachial series rests in part upon the second principal radial piece as well as the third; above or beyond each third radial piece there are for each ray two pairs of pieces wider than long, the distal ones of which extend around the base of the pairs of arms, reaching up to the border of the brachial apertures; interradial pieces one for each space, rudely ovate in shape, longer than wide, the upper end narrow and terminating near the mid-height of the arm bases, and bearing upon the upper end of each a small narrow piece between each pair of arms; anal pieces four, the first one ranging with, but somewhat smaller than the first radials; the next articulating with the first and with the adjacent radials and brachials, and separated from each other by the fourth anal piece, which is higher than wide, and rests by its lower end upon the first; all the pieces of the body tumid, or having a somewhat abruptly raised transverse ridge upon each. Dome considerably elevated, and composed of numerous moderately small tumid pieces, the three which are placed immediately above the bases of each pair of arms being larger and more tumid than the others or even subspinous; the anal area of the dome being also surrounded by a row of similar pieces which bear prominent tubercles; anal area of the dome prominent composed of minute pieces, inflated, almost proboscis-like, the aperture at top directed upward and projecting above the summit of the dome.

Height from base to top of dome, twenty-seven millimeters; height from base to top of arm-bases, 12 mm.; diameter of body including arm-bases, 28 mm.

This differs from all other species of *Agaricocrinus* in the peculiar shape of the anal area of the dome, which is tumid, as just stated, almost proboscis-like, and has its aperture directed upward. It also differs from most of them in the convexity of the lower side, a character which has hitherto been observed only in species of the lower Burlington group.

Position and locality. The only known example of this species was found in the "terrace drift, west bank of the Wabash, at Clinton, Vermillion county, Indiana," owned by Mr. William Gibson. Its exact geological horizon is, therefore, not accurately known, but it probably comes from that of the Keokuk, or lower Burlington division of the Subcarboniferous series. The specific name is given in honor of Frank Springer, Esq., joint author with Mr. Charles Wachsmuth in their able Revision of the Palæocrinoidea.

Genus ONYCHOCRINUS, *Lyon & Casseday.*

ONYCHOCRINUS EXSCULPTUS, *Lyon & Casseday.*

Plate 40, *Fig.* 1.

Onychocrinus exsculptus, LYON & CASSADY. 1860. Am. Jour. Sci., vol. xxix, (2), p. 78.

The following is the substance of the original description of this species as given by Lyon & Casseday, which is copied here because our example is not perfect enough for full description. Calyx vasiform, spreading to the base of the free arms; surface ornamented with minute granules. Basal pieces three, their under surfaces concave, forming a saucer-shaped depression, which was wholly filled by the column. Four of the subradial pieces pentagonal, two of them being larger than the other two, all being distinctly angular at top; the fifth one is hexagonal and somewhat smaller than the other four. Radial pieces generally five to each ray; the first row are large, heptagonal, except in the postero-lateral rays where they are hexagonal; their superior margins are horizontal, on which are imposed the second row of radial pieces; these are smaller than the first, hexagonal, nearly twice as wide as high. The third and fourth rows are similar in form, but become gradually smaller; the fifth row are heptagonal, and support on each beveled edge a row of two or three brachial pieces, which are smaller than the radials. Upon the last brachial pieces rest two arms, which are as long as the body, and composed of stout pieces. These arms have short, stout pinnulæ alternately disposed at their sides.

The interradial pieces vary from twenty to twenty-five; the first being quite large and situated between the rays opposite the first and second radials respectively; the others are smaller, and decrease in size upward.

The foregoing is condensed from the original description of Lyon & Casseday, and to it may be added the following: At the bases of the arms above the third secondary radial pieces, and between each pair of arms there are from one to three small pieces. The sutures between the principal radial pieces are straight, and those between the secondary radial pieces in our example are only slightly sinuate, but the sutures between the joints of the arms are distinctly and somewhat deeply sinnous. The stem is long, round, and rather strong, composed of very numerous pieces of nearly uniform size, but near the body the joints are very thin, and the stem is there a little larger than elsewhere.

The figure on plate 40 is of natural size, and gives a good idea of its size and shape, as well as many of the details of its structure.

Position and locality. Keokuk division of the Subcarboniferous group, Crawfordsville, Indiana.

ONYCHOCRINUS RAMULOSUS, *Lyon & Casseday.*

Plate 39, Figs. 2 and 3.

Forbesiocrinus ramulosus, LYON & CASSEDAY. 1859. Am. Jour. Sci., vol. xviii., (2.) p. 237.

Column moderately large but short, composed of thin pieces of equal size, its upper end entirely concealing the basal pieces of the body or allowing only their edges to appear; subradial pieces comparatively small, much wider than high; primary radial pieces comparatively large, four to each ray, not differing greatly in size; the first one of each ray articulating with each other at their sides and with the subradials below; the second and third pieces of nearly the same size and shape; the fourth piece of similar size and shape with the others, except that it has a sharp projection at the middle of its upper border which partially separates the two secondary radial pieces which rest upon it. The secondary rays are not divided into two equal parts, as the primary rays are, but they give off moderately strong branches at considerable intervals along their sides, there being about four secondary radial pieces of nearly equal, or gradually diminishing size between the fourth piece of the principal ray and the first side branch of the secondary ray, and the intervals between the branches becoming less towards the upper ends of the branching arms in which the secondary rays terminate. The sutures between all the pieces of both the primary and secondary rays are sinuous, being concave at the middle and elevated or convex at the sides; those of the secondary rays a little more deeply sinuous than those of the primary rays. Between the primary rays, adjoining the first, second and sometimes the third radial pieces, there are from one to three or four interradial pieces, all of which are small, but the lower one being much larger than any of the others. There is also a similar set of secondary interradial pieces between the lower portions of each pair of secondary rays. Anal space moderately large, said by Lyon & Casseday to contain from four to six pieces, but they are not satisfactorily discernable in our example. Outer surface of the rays and arms moderately convex and finely granular.

Our example has been somewhat flattened by pressure, and its proportionate width is therefore not satisfactorily determined. Height from the base to the top of the fourth primary ray 19 millimeters; extent of the secondary rays and arms above the latter point about 50 mm.

Position and locality. Keokuk division of the Subcarboniferous series, at Crawfordsville, Indiana.

Genus CYATHOCRINUS, *Miller*.

CYATHOCRINUS MULTIBRACHIATUS, *Lyon & Casseday*.

Plate 39, *Fig.* 1.

Cyathocrinus multibrachiatus, LYON & CASSEDAY. 1859. Am. Jour. Sci., vol. xxviii., p. 245.

Our example, which is well represented by figure 1 on plate 39, is probably identical with the *C. multibrachiatus* of Lyon & Casseday, but as a large part of it is embedded in shale, and the portion which is visible presents some differences from the type of the species according to the original description given by those authors, I am not without some doubt as to its specific identity. Our example seems to have four principal radial pieces to each ray, instead of from three to eight, as stated by Lyon & Casseday. The subradial pieces seem also to be simply convex and entirely free from the broad, faint radiating plications mentioned by those authors; but in other respects our example seems to agree well with their description. Our figure gives so correct a representation of the visible portion of the example that no formal description is attempted, because it would be incomplete at best. Its long, slender, numerous arms, cup-shaped body and moderately strong, round stem will serve for its ready identification.

Position and locality. Keokuk division of the Subcarboniferous series, Crawfordsville, Ind.

Genus PLATYCRINUS, *Miller.*

PLATYCRINUS HEMISPHERICUS, *Meek & Worthen.*

Plate 41, *Fig.* 1.

Platycrinus hemisphericus, MEEK & WORTHEN. 1865. Proc. Acad. Nat. Sci., Phila., p. 162.

Platycrinus hemisphericus, MEEK & WORTHEN. 1868. Illinois Geol. Rep., vol. iii, p. 511.

"Body rather above medium size, hemispherical, being rounded below, and about twice as wide as high: base broad, basin-shaped, and forming about one-third the entire height of the cup, with a pentagonal outline, as seen from below; facet for the attachment of the column between one-third and one-fourth the diameter of the base and subelliptical in outline. First radial pieces larger than the basal, wider than high, nearly quadrangular, and widening moderately from below upwards; facet for the reception of the second radial one-third as wide as the summit and extending down nearly one-fourth the length of the plates, concave and sloping outward, with a deep notch within. Second radial pieces very small, but filling the cavity in each of the first radials, from which they extend out nearly horizontally; pentagonal in outline, and each supporting on its superior lateral sloping margins the first divisions of the arms, which are comparatively small and bifurcate again on the second piece; beyond this the two outer divisions remain simple, but the two inner divide again on the second piece, making six arms to each ray, or thirty to the entire series.

"Arms after the last divisions, long, slender, cylindrical and composed at first of a series of quadrangular pieces, but passing gradually upward into interlocking triangular pieces, and still further up forming a double series of small, alternating, cuneiform pieces, supporting closely arranged, long-jointed tentacles. Anal, interradial and vault pieces unknown; sutures, except between the basal pieces, distinctly but not widely or deeply channeled.

"Surface ornamented with rather small, but well defined, prominent nodes. On the base, these nodes are arranged in ten rows, five of which radiate from the facet for the reception of the column, one to each of the corners, while those between each of these form intermediate radiating rows, consisting at first of a single range, but becoming a double or triple range near the margin, when the three sometimes coalesce laterally. On the first radial pieces two rows pass from just beneath the facet for the reception of the second radials to each of the inferior lateral angles, while between these there is, at first, a single node, but further down two or three rows, consisting of nodes which show a disposition to become elongated, or coalesce laterally, so as to form little transverse ridges; above there is also a row extending horizontally to each superior lateral angle, with a few less regularly arranged nodes on the side below these. A single transversely elongated node sometimes also occurs on the little radials, and one less distinctly defined also sometimes on each of the pieces between this and the next bifurcation.

"Breadth of body at the summit of first radial pieces, 1.07 inches, height of the same 0.60 inch; breadth of base, 0.67 inch; breadth of first radial pieces at the summit, 0.54 inch; breadth of second radials, 0.19 inch."

Position and locality. Keokuk division of the Subcarboniferous series, Crawfordsville, Indiana.

PROTISTA.

PORIFERA.

Genus Palæacis, *Haime.*

Palæacis cuneatus, *Meek & Worthen.*

Plate 41, *Figs.* 8 *and* 9.

Sphenopoterium cuneatum, Meek & Worthen. October, 1860. Proc. Acad. Nat. Sci. Phila., p. 448.

Sphenopoterium cuneatum, Meek & Worthen. 1866. Geol. Sur. Illinois, vol. ii., p. 263, pl. 19, fig. 1, *a*, *b*, *c* and *d*.

Meek & Worthen described this species together with three others of the same genus in the works above cited, under the generic name of *Sphenopoterium*, which they had proposed for them. In the same year, but a few months previously Haime poposed the generic name of *Palæacis* for the same generic forms, and that name therefore takes precedence. The following is a copy of the specific description of the form which is illustrated on plate 5.

"Compressed, cunate, longer than wide; base sharp, a little rounded at the lateral edges; cells from two or three to about five, rather distant, deep, conical, or a little compressed below, and arranged alternately on each lateral edge; rounded or slightly oval at the aperture, and directed obliquely outward and upward; often having one or two slightly prominent ridges extending part of the way up the inside; perforations of the walls numerous and distinct. Surface striæ fine, closely arranged, rather regularly and minutely crenulated, directed obliquely inward and downward from the apertures of the cells, and passing more or less nearly parallel to each other, to the base, on the lower flattened portion. Length, 0.75 inch; breadth, 0.50 inch; thickness, 0.22 inch."

Position and locality. Warsaw division of the Subcarboniferous series, Spergen Hill, Washington county, Indiana.

COAL MEASURES.

MOLLUSCA.

GASTEROPODA.

Genus POLYPHEMOPSIS, *Portlock*.

POLYPHEMOPSIS NITIDULA, *Meek & Worthen*.

Plate 42, Figs. 7 and 8.

Polyphemopsis nitidula, MEEK & WORTHEN. Geol. Sur. Illinois, vol. ii, p. 374, pl. 31, figs. 9 a and b.

The shell figured on plate 42 is referred, with some doubt, to *P. nitidula*, Meek & Worthen. One shell seems to have much the same form and general characteristics of their type, but is a little more elongate, and the volutions are a little less convex. These differences, however, seem only to be varietal, and therefore the description of the species as given by those authors is here copied.

"Shell of medium size, subfusiform, spire elongated, conical, rather attenuate and acutely pointed above. Volutions eight to eight and a half, rather convex, last one comparatively large, composing less than two-thirds the entire length, somewhat contracted and produced below. Suture well defined, especially between the lower whorls. Aperture narrow, subovate, a little oblique and acutely angular above, rather narrow, and apparently provided with a small rounded sinus at the base of the columella below. Outer lip thin and sharp, with a slightly prominent margin. Columella arcuate, and somewhat twisted below; inner lip nearly or quite obsolete above. Surface smooth, but showing under a magnifier extremely fine, obscure lines of growth. Length 1.10 inches; breadth, 0.43 inch; apical angle regular, divergence 30°; length of aperture, 0.47 inch; breadth, 0.20 inch."

Position and locality. Coal measure strata, Eugene, Vermillion county, Indiana.

CONCHIFERA.

Genus NUCULA, *Lamarck.*

NUCULA VENTRICOSA, *Hall.*

Plate 42, *Figs.* 9 *and* 10.

Nucula ventricosa, HALL. 1858. Geology of Iowa, part ii, p. 716, pl. 29, figs. 4, 5.

There is no room for doubt that the species which is represented by figures 9 and 10, on plate 42, is identical with the *N. ventricosa* of Hall, and it is not improbable that the latter is really a synonym of *N. tumida*, Phillips; but as I have no means at hand for satisfactory comparison, I prefer to use the name which has been proposed by Professor Hall. The following is a copy of his description of the species as given in the work cited.

"Shell ovoid, gibbous or subventricose on the middle and upper part of the shell; outline regularly curving to the base and posterior extremity; beaks near the anterior extremity incurved and inclining forward, with a cordiform depression beneath them. Surface marked by fine concentric striæ and some stronger lines of growth. Hinge line, marked on the posterior side of the beak, by thirteen or fourteen small, prominent teeth,

which increase in strength as they recede from the beak: anterior side with several small teeth, and two others much stronger, with a deep pit between; muscular impressions strongly marked; shell thickened just within the margin."

Position and locality. Coal measure strata, Sullivan county, Indiana.

BRACHIOPODA.

Genus SPIRIFER, *Sowerby*.

Sub-genus MARTINIA, *McCoy*.

SPIRIFER (MARTINIA) LINEATUS, *Martin*.

Plate 42, Figs. 4, 5 and 6.

The shell which is here figured is one which has usually been referred to *Spirifer lineatus* Martin, but which McChesney described under the name of *S. perplexa*. Although it very closely resembles *S. lineata*, one can hadly be satisfied that it is really specifically identical, and it is probable that we shall be justified in adopting McChesney's name. Not having the means for direct comparison with the European form at hand, however, I prefer to leave our shell for the present with *S. lineatus*, where it has been placed by the majority of paleontologists who have noticed it: making the following brief description:

Shell moderately gibbous, transversely subelliptical in marginal outline, the front and sides regularly rounded; hinge much shorter than the width of the shell: cardinal extremities rounded; cardinal area distinct, arched and moderately high. Ventral valve convex: umbonal portion prominent; beak prominent, incurved; area small; without median sinus, but there is a slight flattening of the valve at the front which gives the front margin a very slight sinuosity. Dorsal valve regularly convex, both transversely and logitudinally; umbonal portion prominent, but not so much so as that of the other valve; beak moderately prominent and projecting a little beyond the hinge line. Surface marked by numerous very faint radiating lines and somewhat stronger concentric lines; the latter being impressed and finely crenulate, the minute crenulations apparently marking the bases of hair-like spines when the surface of the shell was perfect.

Length from ventral beak to front, 17 millimeters; breadth, 18 mm.; greatest thickness, both valves together, 13 mm.

Position and locality. Coal measure strata, Eugene, Indiana.

Genus PRODUCTUS, *Sowerby*.

PRODUCTUS PUNCTATUS, *Martin*.

Plate 42, *Figs.* 1, 2 *and* 3.

This is one of the best known species of characteristic coal-measure fossils, and one the specific identity of which with the European form of that name has never been seriously questioned. The following description applies to the species as it exists in widely separated localities in the United States.

Shell large, test thin; marginal outline varying from imperfectly four sided, the narrowest side being the posterior one, to subovate, sometimes being wider than long, but sometimes longer than wide; cardinal margin almost invariably shorter than the width of the shell at any part in front of it; anterior border broadly rounded but usually a little emarginate at the middle; sides flattened, by which means the lateral margins are somewhat straightened; ears small. Ventral valve broadly arcuate from front to rear, in which direction there is also a broad mesial flattening of the valve, with usually a shallow but somewhat distinct mesial sinus along its middle; umbo prominent, narrow; beak small, incurved and projecting slightly over the cardinal border. Dorsal valve moderately concave; beak as such wanting, its place being concave; mesial fold ill defined, there being only a slight mesial elevation of the valve extending along the visceral and anterior portions.

Surface of both valves marked by rather numerous and regular concentric folds, which are smaller at the beak and borders than elsewhere, upon adult shells, and smaller and more distinct upon the dorsal than upon the ventral valve; interspaces between the concentric folds plain; folds supporting numerous spines of varying size, but all minute and more or less appressed against the shell.

Length of the example figured, which is of adult size, 67 millimeters; breadth of the same at the broadest part, about the same as the length.

Position and locality. Coal measure strata, Newport, Indiana.

FOSSIL PLANTS.

Genus TAONURUS.

TAONURUS COLLETTI, *Lesquereux.*

Plate 43, *Fig.* 1.

Chondrites colletti, LESQUEREUX. 1870. Ills. Geol. Rep., vol. iv, p. 379.
Taonurus colletti, LESQUEREUX. Vol. P., Atlas Coal Flora, 2d Geol. Sur. Penna., pl. A, fig. 7.

The following is a copy of the description of this species as given by Professor Lesquereux:

"Frond large, dividing fan-like into numerous crowded branches, dichotomous, either diverging on both sides of the main axis or arched on one side; ultimate divisions simple, linear, cylindrical, with irregular borders.

"This species is not as yet satisfactorily known. I have received from Mr. John Collett, of Eugene, Indiana, some specimens of a black fossiliferous limestone, whose surfaces are marked with the remains of these plants, true Fucoides. The species distantly resembles, by the curving of its branches, *Fucoides cauda-galli*, Vanuxem. But it is evidently a compound of separate branches, dichotomous from near the base of the frond (the base is broken from the specimen), the branches in dividing and ascending, forming fan-like or flabellate fronds. The branches, which are ultimately simple, leave upon the stone a half-cylindrical impression and are distinct from each other."

Position and locality. Coal measure strata, falls of Mill creek, Fountain county, Indiana.

Genus SPHENOPHYLLUM, *Brongniart.*

SPHENOPHYLLUM SCHLOTHEIMI, *Brongniart.*

Plate 43, *Fig.* 2.

The following is a copy of the description given of this plant by Professor Lesquereux, in his coal flora of Pennsylvania:

"Verticils of five to nine leaves; leaves broadly cuneate, rounded and crenulate at the upper border; veins free at the base, much divided; spikes thick, cylindrical.

"This species, the most common and most beautiful of the genus, is easily known by the undivided rounded upper borders of the leaves, which often appear entire or very slightly crenulate, but are sometimes acutely dentate. The whorls vary much in diameter, the leaves being from one-half to nearly two centimeters long and equally as variable in width. The spikes are rarely found attached to stems bearing leaves, and therefore it is rarely possible to refer them to their species."

Position and locality. This species ranges throughout the whole thickness of the coal measures, and is found from Pennsylvania to the Mississippi valley. The specimen figured on plate 43 is from Shelburn, Sullivan county, Indiana.

SPHENOPHYLLUM EMARGINATUM, *Brongniart*.

Plate 43, *Fig.* 3.

This species, like the last, is described by Prof. Lesquereux in his admirable Coal Flora of Pennsylvania, of which description the following is a copy:

"Leaves narrower [than those of *S. schlothcimi*], truncate at the top, obtusely dentate, primary nerves confluent at the base.

"This species differs from the former merely by proportionately longer, narrower leaves, cut horizontally (not rounded) at the upper margin, and the primary veins joined at the base and less divided. The species is easily confounded with the former."

Position and locality. The specimen figured on plate 43 is from Lebanon, Warren county, Indiana.

VAN CLEVE'S FOSSIL CORALS.

The fossil corals which are represented on plates 44 to 55, inclusive, as has before been stated, were many years ago studied by Mr. J. W. Van Cleve, with the view to their publication, and the figures referred to were all engraved by his own hands. His death prevented the publication of his work, and the names he had applied to the species have all been superseded by those of subsequent authors. I have, therefore, made no use of his manuscript, but identifying his figures from the published descriptions of other authors, I have either copied those descriptions, or have given the substance of them in other words. This portion of the present article is, therefore, wholly one of compilation, and one in which I claim no proper authorship.

LOWER SILURIAN.

Genus STREPTELASMA, *Hall.*

STREPTELASMA CORNICULUM, *Hall.*

Plate 51, *Figs.* 2, 3 *and* 4.

The following is Prof. Hall's original description of this species, Vol. I, Paleontology of New York, p. 69:

"Turbinate, curved near the base, which terminates in an acute point, somewhat rapidly expanding above; cup profound; lamellæ about sixty; surface marked by strong longitudinal lines indicating the lamellæ, which are crossed by fine concentric wrinkled lines. Length varying from three-fourths to one and a half inches."

The foregoing description was made from specimens collected from the Trenton group of New York. It occurs abundantly in the lower Silurian strata of Ohio and Indiana, specimens of which are often found several inches in length, being much larger than those mentioned by Prof. Hall. It is likely to be found in those counties of Indiana which adjoin Ohio, from Wayne county southward. This species has frequently been published under the generic name of *Petraia*, but Munster's generic description of *Petraia* will not apply to the structure of the coral here described and figured.

Genus PALÆOPHYLLUM, *Billings*.

PALÆOPHYLLUM DIVARICANS, *Nicholson*.

Plate 52, *Fig.* 4.

The species represented by figure 4, on plate 52, seems to be identical with that which was described by Dr. Nicholson in Vol. II, Paleontology of Ohio, p. 220, under the name of *Palæophyllum divaricans*. The following is a copy of his description:

"Corallum usually free, sometimes apparently attached, compound, formed of conical turbinate corallites, which are produced by lateral gemmation, or rarely by fission, and which are directed outward from the parent, usually at a more or less open angle, and are never in actual contact with each other.

The number of corallites in a corallum, so far as observed, varies from two to six. Septa from fifty-eight to sixty-two, alternately large and small, the large ones becoming twisted as they approach the center of the visceral chamber, where they unite with one another laterally and form a more or less developed central mass of vesicular tissue. No dissepiments nor columella. Tabulæ unknown. Wall with a well developed epitheca, with longitudinal ridges corresponding with the septa within, and also with faint encircling striæ and a few shallow annulations of growth. Calices deep, with a flattened space at the bottom. Free edges of the septa not furnished with spines or denticulations. Apparently no fossette.

"The best preserved specimen which has come under my notice consists of two corallites, one budded from the side of the other nearly at right angles. The largest corallite has a length of nearly ten lines, a diameter of calice of seven lines and a depth of calice of four lines. Another specimen consists of six nearly equally sized corallites, apparently produced by parietal gemmation, and having a length of five or six lines, and a diameter at the calice of about five lines. Another specimen consists of two large corallites which appear to have been produced by fission, being attached only by their pointed bases, and being nearly in contact with one another. The length of the largest of these corallites is more than an inch and a half, and its diameter at the calice is ten lines. Another specimen, precisely similar in its mode of growth, is attached to the dorsal valve of *Rhynchonella dentata*, Hall, the length of the largest corallite being only three lines and the diameter of the calice of the same.

"The specimens from which the above description was taken, in most respects closely resemble *Streptelasma corniculum*, Hall, especially as concerns their twisted septa; but they possess a much smaller number of septa (if specimens of the same size be compared) and they are always rendered composite by the production of lateral buds or by cleavage."

Position and locality. Professor Nicholson's specimens were obtained from the Cincinnati Group at Cincinnati, and Mr. Van Cleve obtained his specimens from near Dayton, Ohio. The species is likely to be discovered in those counties of Indiana which border upon Ohio, from Wayne county, southward.

Genus FAVISTELLA, *Hall.*

FAVISTELLA STELLATA, *Hall.*

Plate 44, *Figs.* 1 *and* 2.

Corallum forming an irregular compact or sub-hemispherical mass; corallites prismatic, varying in diameter from 2 to 4 millimeters, the average being about 3 millimeters; the number of sides of each corallite varying from three to seven, according to the number of other coralites with which it is in contact, but the number of sides is usually six; radiating septa unequally developed, alternately large and small; the larger septa from twelve to fifteen in number, reaching to the center of the corallite or nearly so; small septa rudimentary, projecting but slightly from the margin; tabulæ numerous, complete, no columella.

Position and locality. This coral, like the two preceding species, is characteristic of the Lower Silurian strata, and has been found at various widely separated localities in the United States and Canada. It may be looked for in Wayne, Union, Franklin, Dearborn, Ohio and Switzerland counties of Indiana.

Genus PROTAREA, *Edwards & Haime.*

PROTARÆA VETUSTA, *Edwards & Haime.*

Plate 49, *Fig.* 4.

Corallum forming a thin encrustation upon shells, other corals, or upon some foreign body, of less than a millimeter in thickness; calyces shallow, of nearly uniform size, usually hex-

agonal, from one to two millimeters in diameter; radiating septa twelve in number, nearly equal, not extending to the center of the calyx, the bottom of which is tuberculated; separating walls of the calyces comparatively thick.

Position and locality. This handsome little coral is also widely distributed in the lower Silurian rocks of North America. It is likely to be discovered in the strata of the counties of southeastern Indiana, which have been mentioned in connection with the preceding species.

Genus CONSTELLARIA, *Dana.*

CONSTELLARIA ANTHELOIDEA, *Hall.*

Plate 46, Figs. 1, 2 and 3.

The following is a copy of Prof. Nicholson's description of this species as given in Vol. II, of the Paleontology of Ohio, p. 214:

"Corallum composed of palmate or sub-palmate expanded fronds, or flattened stems, which must have grown in an erect position, attaining a height of two inches or more, and having a thickness of from one and a half to two lines. Surface polypiferous on all sides, the corallites cylindrical, radiating in all directions from an imaginary central plane or axis. Scattered over the entire surface are numerous conspicuous, more or less prominent stars, each of which has a diameter of one line or a little less, and is composed of a central, sometimes depressed, smooth area, and of generally from six to eight prominently elevated ridges, which radiate from the central space, and occasionally have smaller rays intercalated between them. The stars are usually circular in shape, sometimes elongated or elliptical, and generally arranged in irregular oblique or transverse rows, two stars usually occupying a space of two lines and a half. The central area of each star is minutely pitted or porous, being apparently composed of very minute tubuli, but appears to be solid, unless examined with a sufficiently high magnifying power.

The elevated rays of the stars, and all the comparatively depressed portions of the surface between the stars are covered with small circular calices, of which ten or twelve occupy the space of one line. The calices are sometimes in contact, but they are more usually separated from one another by half their own width or more. The spaces between the calices appear to be sometimes solid, but they are more commonly minutely tubular, this latter condition almost certainly representing the true structure of the coral. The corallites exhibit no traces of septa, but well developed, though delicate tabulæ."

Professor Nicholson has described another species of the same genus under the name of *C. polystomella*, which he found associated with the former species in the lower Silurain rocks of Ohio. It is probable that figure 2 on plate 10 was drawn from an example of that species, but this is not certain. Figures 1 and 3, however, will enable any one to recognize the species here described, without hesitation.

Position and locality. This species, like the preceding ones, has a wide distribution in the lower Silurian rocks of North America, and it may be looked for in the strata of those counties of Southeastern Indiana, which have been named in connection with the description of *Favistella stellata*, on a previous page.

Genus MONTICULIPORA, *d'Orbigny.*

MONTICULIPORA FRONDOSA, *d'Orbigny*

Plate 48, Figs. 2 and 3.

This, together with numerous other species which are associated with it, and many others that are found in other formations, have, until lately, all been referred to the genus *Chætetes*. This species has accordingly long been known as *Chætetes frondosus*. As shown by Professor Nicholson and others, however, it clearly belongs to the genus *Monticulipora* of d'Orbigny. The following is Professor Nicholson's description of the species as given in Paleontology of Ohio, Vol. II, p. 208:

"Corallum forming erect, flattened, undulating expansions, polypiferous on both sides, of unknown, but considerable height, and varying from less than one line to three lines in thickness. Calices sub-circular, from eight to ten in one line, almost or quite half their diameter apart, separated by numerous very small cylindrical tubuli, which render the spaces between the corallites minutely porous. Surface with stellate or sub-circular spaces, which may either not project at all, or may be elevated in the form of low, rounded tubercles, and which are occupied by minute tubuli similar to those which separate the ordinary tubuli. Often the corallites immediately surrounding these spaces are larger than the average, the tubercles being usually arranged in irregular diagonal lines and placed at distances of about one line apart.

"I am not at all satisfied that the specimens from which the above description is drawn, are really referable to the form described by d'Orbigny under the name of *Monticulipora frondosa;* but not having at this moment access to this author's description, I provisionally describe our examples under this name. Should they prove to be distinct the specific name of *ohioensis* might be applied to them.

"Many of the examples of this species appear to have attained a large size, and are now only to be found in a broken condition. Mr. U. P. James, however, has furnished me with a number of nearly perfect specimens, which have the form of small flattened fronds, about an inch or an inch and a half in height, and three-quarters of a line in thickness, which would appear to be young examples of this form."

Position and locality. This is a very common fossil in the lower Silurian series of Ohio, and it is also common at some points in Southeastern Indiana; and it is likely to be found at numerous places in those counties which border upon Ohio, which have already been mentioned in connection with the description of the five preceding species, all of which species belong to strata of lower Silurian age.

UPPER SILURIAN.

Genus LYELLIA, *Edwards & Haime.*

LYELLIA AMERICANA, *Edwards & Haime.*

Plate 47, *Fig.* 5.

The following is a free translation of the original description as given by Edwards & Haime in their *Monographie des Polypiers Fossiles des Terrains Palæozoïques*, p. 226.

Corallum elevated, expanded; calyces separated from each other generally by one or two times their diameter, circular, prominent, the surface of the cœnenchyma finely reticulated; radiating septa twelve in number, well developed, alternately a little unequal, thinning inwardly; diameter of the calyces a little more than two millimeters. A vertical section (of parts that have not been altered by fossilization) show a cœnenchyma composed of convex vesicles, very unequal, but generally large.

Position and locality. This species is characteristic of the Niagara group of the upper Silurian age. It is not a very abundant fossil, but it is found at somewhat widely separated localities in the United States, and is likely to be found in eastern Indiana, for example in Clark, Shelby and Decatur, counties.

Genus HALYSITES, *Fischer*.

HALYSITES CATENULATA, *Linnæus*.

Plate 46, *Figs*. 4, 5, 6 *and* 7.

This is one of the most common and one of the most readily recognizable of all the fossil corals. It has been described by various authors under different names and as different species, based mainly upon the differences in size of the corallites. Specimens showing two different sizes of corrallites are illustrated on plate 46, and specimens are frequently found with corallites still smaller than the smallest of these.

It seems hardly necessary to describe this well known coral, except in a general way. The corallum is made up of vertical plates, which are joined together by their edges in such a manner as to leave between them open vertical spaces of irregular size and shape. The vertical plates are composed of the corallites, which are joined close together side by side throughout their whole length, the plate being only one corallite in thickness. So joined, the oval open mouths of the corallites, generally retaining a nearly uniform height and present the appearance of delicate chains. The tabulæ of the corallites are somewhat numerous and well developed, and the radiating lamellæ are occasionally to be seen, and are rarely found to be very distinct. The long diameter of the corallite is always in the direction of the length of the chain, and it varies in different examples from less than one millimeter to more than three millimeters.

Position and locality. This is one of the most characteristic fossils of the Upper Silurian rocks of North America, being common to both the Clinton and Niagara groups. It may be sought for in all parts of the State of Indiana in which either of these formations is present at the surface—Clark, Jefferson, Shelby, Decatur, Delaware, Wabash, etc.

Genus HELIOLITES, *Dana.*

HELIOLITES ELEGANS, *Hall.*

Plate 48, *Fig.* 4.

Figure 4 on plate 48 seems to have been drawn from an example of *Heliolites elegans*, Hall. It does not show the minute rays which mark the mouth of each corallite in perfect specimens; but the general aspect of the surface represented is that of ordinary examples of the species. The following is a copy of Prof. Hall's original description, from Vol. II, Paleontology of New York, p. 130:

"Coral massive or hemispheric, increasing by the lateral addition of cells more than by interstitial additions; cells small, sixteen to eighteen in an inch; openings upon the surface marked by twelve or more short rays; transverse septa numerous; interspaces apparently lamelliferous.

"The coral presents a variable surface appearance, from the different influences of weathering; when it has suffered little or nothing from such causes, the entire surface presents a series of stars having a depression in the center, and apparently confluent at the margins; where it has been slightly weathered or worn, the stars are limited, and in many cases there is a solid crystalline center with surrounding rays. A polished transverse section presents the cells with the space between them equal to the diameter of the cell. A vertical section gives the same general appearance."

Position and locality. This coral was originally described from the Niagara group of the State of New York. It is likely to be found in the strata of that group in Indiana.

Genus FAVOSITES, *Lamarck.*

FAVOSITES FAVOSUS, *Goldfuss.*

Plate 52, *Figs.* 1 *and* 2.

Figure 1 on plate 52 very accurately represents the upper surface of a corallum of this species which has been completely weathered out of the imbedding rock, and showing the open mouths of the corallites. Figure 2 represents a few of the separated corallites with the fine communicating mural pores in their vertical walls. The following is Dr. Nicholson's description of this species as it exists in North American rocks (for it is also a European species), copied from his report on the Palæontology of Ontario (1875), page 52:

"The corallum in this species is massive and in all respects quite like *F. gothlandica*, except for the fact that the tabulæ are strongly and uniformly curved, with their convexities upwards. The corallites are prismatic, from one line to one and a half lines in diameter; the tabulæ are about six in the space of two lines; the mural pores are in two alternating rows upon the faces of the corallites, and the septa are represented by spiniform projections."

Position and locality. *Favosites favosus* is a characteristic coral of the Niagara group, and it may be sought for in strata of that age in those parts of Indiana where they are known to occur. Several other species of *Favosites*, some of them closely resembling this, may also be found in the State, but those will be likely to be found in the rocks of Devonian age, and some of them will be described on subsequent pages.

Genus CLADOPORA, *Hall.*

CLADOPORA RETICULATA, *Hall.*

Plate 47, Fig. 6.

The following is a copy of Professor Hall's original description of this handsome and delicate coral, from Paleontology of New York, Vol. II, page 141:

"Coral expanded into a broad reticulate frond; branches roundish or slightly flattened, coalescing at frequent intervals and forming meshes of various form and size, poriferous on all sides; openings of the cells upon the surface roundish or oval, distant from each other rather more than their diameter, often arranged in parallel longitudinal lines; interior showing the cells reaching to the center from all sides, and, in solid specimens, becoming prismatic. Cells distant from each other one-sixty-fourth of an inch.

"This species has the general aspect of a *Retepora*, but a slight examination proves it poriferous on all sides, having round, tubular cells, which, in perfect specimens, open upon the surface in nearly circular mouths, having a projecting lip upon the lower side. In slightly worn branches, the openings are quite circular; and in those more worn they become somewhat angular. From unequal wearing the openings sometimes appear oval; and from other causes specimens often present a variety of appearances. The spaces between the mouths of the cells are slightly greater than the width of the openings themselves, and, in longitudinal sections, this is distinctly seen penetrating to the axis, while the cell appears like a gradually enlarging tube from the center to the surface of the branch."

Position and locality. The specimens from which Professor Hall drew this original description were obtained from strata of the Niagara group near Louisville, Kentucky, and the species is likely to be found in Indiana wherever the strata of that group occur.

Genus CLATHROPORA, *Hall.*

CLATHROPORA FRONDOSA, *Hall.*

Plate 55, Fig. 3.

This form bears, at least, some general resemblance to the one last described, but it is in reality very different, belonging to the class Polyzoa, and not like the former, to the Hydrozoa. The species was originally described from the Niagara shale at Lockport, New York, and the following is Professor Hall's description, copied from *Paleontology of New York*, Vol. II, p. 160.

"Frond reticulate, expanded, flabbellate or funnel-shaped; the two surfaces regularly and equally celluliferous; cells with rhomboidal or oblong quadrangular apertures opening obliquely upward; tubular cells reaching to the centre and gradually enlarging towards the aperture.

"This species consists of a thin, expanded frond, produced by the anastomosing of broad, flattened branches. It appears more like a perforated flabellate frond, than a reticulate structure. It has the general appearance of *Retepora*, from which it is not readily distinguished unless both sides are examined. The form of the apertures of the cells, however, is more quadrangular than in any species of *Retopora* I have seen, and this character may be of service in deciding the reference of specimens. It usually occurs in the soft shale, one side adhering to the stone from which it is necessary to remove some portions of the coral before its real character can be ascertained. Portions of fronds, six inches or more in diameter in every direction, have been obtained, and which are imperfect on all sides, showing that the coral attained a large size. From the mode of divergence of the frond from the center, it appears that the perforations are arranged in concentric circles, each row or circle having successively been at the outer margin of the frond."

Position and locality. This species is likely to be discovered in the strata of the Niagara group where they may occur in Indiana.

DEVONIAN.

Genus ACERVULARIA, *Schweigger.*

ACERVULARIA DAVIDSONI, *Edwards & Haime.*

Plate 49, *Fig.* 2.

Coral forming sub-turbinate or sub-hemispherical masses, with the upper surface convex or nearly plane; corallites irregularly polygonal, unequal in size, borders of the calyces slightly zig-zag; interior wall indistinctly defined, its position indicated by a circular, slightly pronounced fold which circumscribes a calyx of moderate depth; rays from thirty-two to forty in number in the larger corallites, and less in the smaller, distinctly crenulate or even denticulate at the outer portion, but less so at the inner; a small papilliform elevation is sometimes to be seen at the bottom of the central pit of the calyx. Diameter of the corallites, 10 to 12 millimeters; diameter of the central pits, 4 or 5 mm.

The corallum of this species sometimes reaches a foot in diameter, but the masses are usually much smaller.

Position and locality. The type specimens of this species were obtained from the Devonian rocks at Jeffersonville, Ind., and the original description was published in France, in the work already quoted. It is quite a common fossil also in the Devonian strata of Michigan and Iowa.

Genus DIPHYPHYLLUM. *Lonsdale.*

DIPHYPHYLLUM ARCHIACI, *Billings.*

Plate 50, *Fig.* 1.

The following is the original description of this coral, as given by Mr. Billings, in the Canadian Journal, new series, Vol. V, page 260:

"Corallum forming large masses of parallel, nearly straight, cylindrical stems, in contact with each other, or nearly so and which, when full grown, are from six to eight lines in diameter, The young stems are added by lateral or marginal gemmation, and are at first two or three lines in diameter, their adult size being attained at the length of two or three inches. At the diameter of four or five lines there are between thirty and thirty-five radiating septa; at six or eight lines, usually about fifty; but occasionally in those of the larger size, from seventy-five to eighty may be seen.

"Fifty appears to be the common number. There are two or three transverse diaphragms in the length of one line. In most of the corallites there is a central area, one line or a little less in diameter into which the radiating septa do not penetrate. Others in the same mass seem to be without this central area. Surface with a somewhat thick epitheca, which, where perfectly preserved, is beautifully ornamented with fine crowded encircling striæ, from fifteen to twenty in the width of one line. In addition to these fine striæ, there are numerous, usually sharp-edged annulations, varying from less than one-fourth of a line in width and depth, to one or two lines. Some of the corallites exhibit sudden constrictions of growth, which give to them the appearance of a series of short turbinate stems inserted into each other.

"The epitheca is often entirely or partially worn away, and the fine striæ can only be seen when the surface is in a very perfect state of preservation. It is probable this coral occurs simple as well as aggregate."

Position and locality. This species is somewhat common in the strata of the Hamilton group of different parts of Canada, where it is originally described. It is found in all the Devonian strata of Indiana, which have afforded perhaps a greater variety of fine fossil corals than those of any other State.

DIPHYPHYLLUM STRAMINEUM, *Billings*.

Plate 48, *Fig.* 1.

"Corallum forming large masses of cylindrical tubes, averaging two lines in diameter, and either so closely aggregated as to be nearly in contact, or separated from one another by intervals of from one to five lines, the distance varying in different clusters and in different parts of the same. Sometimes numerous single tubes occur scattered through the rock, which were probably derived from some disintegrated group. The tubes are either straight or flexuous, smooth or annulated by short encircling folds of growth, the surface striated longitudinally by the outer edges of the septa. The latter are forty in number and do not reach the center. The transverse diaphragms are well developed, slightly convex in the center, and appear to be suddenly turned down on approaching the margin. The outer vesicular area is thin, seldom exceeding one-sixth of the whole diameter. The central area altogether occupied by the transverse diaphragms; sometimes in well-preserved specimens the septa may be seen extending about half way to the center, upon the surface of some of the diaphragms, but in general they are confined to the outer area. In the more dense colonies, the corallites often inosculate, and are sometimes connected by lateral processes, as in the species of the subgenus *Eridophyllum*."

The above description is copied from Billings' description, in Canadian Journal, New Series, Vol. IV, p. 135. Prof. Nicholson, in commenting upon it, says he doubts if the distinctness of this species from *Diphyphyllum gracile*, McCoy, can be maintained. Mr. Billings also admitted the close similarity of the two species, but claimed that the slight differences observable in the American specimens, from the European ones, are of specific importance.

Position and locality. The type examples of *D. stramineum* were obtained from the Corniferous limestone of Canada, but it may be reasonably sought for in the equivalent strata of Indiana, especially in the counties of Clark, Decatur, Shelby, Bartholomew, Cass, Carroll, Jasper, etc.

DIPHYPHYLLUM ARUNDINACEUM, *Billings*.

Plate 51, *Fig.* 1.

This species was also described by Mr. Billings in the same work, he having found his type specimens associated with those of *D. stramineum*. The following is his description, copied from the Canadian Journal, New Series, Vol. IV, p. 134:

"Corallum forming large masses of long cylindrical straight or flexuous stems, from three to four lines in diameter, but usually distant from one to three lines from each other; radiating septa thin, between forty and fifty in number, rarely reaching to the center; transverse diaphragms turning downward, on approaching the margin; two to four in one line. In some of the corallites the walls are so thin and closely united that no separation can be observed, but in others of the same cluster an outer area is distinctly visible. There is usually a circular space in the center of the corallites into which the radiating septa do not penetrate; often, however, they reach the center. The young corallites sometimes spring from the sides of the parent with a slender base, and curving upwards immediately become parallel with those of the whole group. In large colonies frequent instances may be seen where, instead of this lateral budding, a bifurcation takes place, both branches being of the same size. In large groups, owing to numerous additions of young, the corallites diverge slightly, as if radiating from a point. The colonies are from six inches to several feet in diameter, and large blocks of stone are of frequent occurrence which are penetrated at right angles to the stratification by the closely crowded stems."

Professor Nicholson, in commenting upon this species,* says it is distinguished from *D. stramineum*, the species last described, "chiefly by the almost uniformly greater size of the corallites, which average three or four lines in diameter when fully grown. In shape the corallites are cylindrical, with annulations and constrictions of growth; they may be straight or more or less flexuous, and they vary in their distance apart. The epitheca is marked with numerous extremely close-set and delicate encircling striæ, together with more or less conspicuous vertical striæ, which mark the position of the septa within. Occasionally the corallites are united by lateral connecting processes derived from the epitheca, similar to those which characterize the genus *Eridophyllum;* but these processes are always remote and are only an occasional feature. The septa are from forty to forty-two, alternately large and small, and rarely encroaching upon the central tabulate area. The tabulæ are regularly depressed and bent downward as they pass through the outer vesicular zone on their way to reach the margin; but they are sometimes more or less flexuous. Increase of size, so far as I have observed, seems to be always by the production of lateral buds, but it is possible that calycular gemmation sometimes occurs, and Mr. Billings states that bifurcation of the corallites takes place occasionally."

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* Paleontology of Ontario, 1874, p. 32.

Position and locality. Since *D. stramineum* and *D. arundinaceum* are associated together in the corniferous strata of Canada, it is probable that they will be found thus associated in at least some of the Devonian strata of Indiana; especially so because of the fact that the latter species has been observed in strata of that age in Iowa, showing its wide geographical distribution.

Genus ERIDOPHYLLUM, *Edwards & Haime.*

ERIDOPHYLLUM STRICTUM, *Edwards & Haime.*

Plate 49, Fig. 1.

This is another species which Edwards & Haime obtained from the Devonian strata near Jeffersonville, Ind., and published in their great work, Monographie des Polypiers Fossiles. The species is also known to occur at various other places in the United States and in Canada. The following description of it is copied from Dr. Nicholson's Report on the Paleontology of Ontario (1875), p. 74:

"Corallum fasciculate, of elongated cylindrical corallites, which have a diameter of from two to five lines, and are placed at intervals varying from half a line to two lines apart. The corallites are sometimes annulated by sharp epithecal projections at intervals of from one and a half to three lines, and at each of these annulations arise small processes by which the separate corallites are united to one another. At other times these periodic annulations and the processes which spring from them, are not nearly so well marked, and may hardly be developed at all. In any case, the epitheca is marked by longitudinal and fine encircling striæ, of which the latter often have an oblique direction. Increase is chiefly or entirely by calycular gemmation, three or four young being often produced simultaneously from the oral disc of the parent corallite.

"A well marked internal tabulate area is present. The septa are well developed in the external area of the corallites, where they are united by delicate dissepiments. The septa are apparently alternately developed, and rarely encroach much upon the internal tabulate area, their number seeming to be about sixty in a full-sized corallite.

"This species is somewhat variable. The specimens which I have seen from the Corniferous limestone of Ohio and Kentucky exhibit, very conspicuously, periodic annulations of growth, from which the connecting processes are developed in a whorled manner; but this feature is not marked in the Canadian specimens."

Position and locality. Devonian strata near Jeffersonville, and other parts of Indiana.

Genus CYSTIPHYLLUM, *Lonsdale.*

CYSTIPHYLLUM VESICULOSUM, *Goldfuss.*

Plate 55, *Figs.* 1 *and* 2.

This is another American form which is identified with a well known European species. It is widely distributed in the Devonian rocks of the United States and Canada. It is very variable in outward form, but the characteristic vesiculose structure is constant and easily recognized, even without making sections of the corallum. The following description, by Dr. Nicholson, is copied from his Report on the Paleontology of Ontario (1874), page 37:

"Corallum simple, elongated, turbinate or cylindro-conic, sometimes nearly cylindrical. Epitheca exceedingly strong, exhibiting numerous fine encircling striæ, along with many well-marked annulations of growth, which sometimes have the form of circular wrinkles, but which at other times are sharp-edged and imbricating. Not uncommonly the folds of the epitheca are laterally prolonged in the form of wing-like extensions. Calice very deep, its walls extraordinarily thickened in aged examples and its bottom usually occupied by a group of bullæ. Septal striæ in the interior of the calice usually very distinct, but appearing to be made up of a succession of elongated vesicles. Internal structure vesicular, the largest of the vesicles being central, and having a diameter of a line to a line and a half. Young individuals are truly simple, but older examples increase by calicular gemmation, a succession of vertically superimposed corallites being thus produced. In an individual of average size, the length is three inches; the diameter of the calice is an inch and a quarter, and the depth of the calice is an inch and a quarter. Large individuals occur, however, in which the length must have been half a foot, and a foot, whilst the diameter is nearly three inches.

"Our specimens agree exactly with those figured by Goldfuss, and there can not be the smallest doubt as to their identity.

"Our specimens show also in a most marked manner, a feature which is present in most of the examples figured by Goldfuss, viz., growth by means of calicular gemmation. In this peculiar mode of increase the coral attains a certain growth, and the calice becomes then more or less obliterated by the extension over it of the epitheca. Then a new bud is thrown up from the calice, generally directly above the old one, and this too continues to grow for a certain period. A third, fifth, or sixth may be similarly produced, until the entire corallum may consist of a series of short turbinate cups, or inverted cones, superimposed one above the other, the younger upon the older. As the direction of the new cups does not always accord with that of the old ones, the general form produced by this mode of increase is often very peculiar and irregular. Some specimens also show extraordinary lateral prolongations of the epitheca."

The figures prepared by Mr. Van Cleve, and which are given on plate 55, were no doubt taken from a specimen of *C. vesiculosum*, but it was evidently one from which all, or nearly all the epitheca had been removed by weathering or other causes. These figures, however, well represent the condition in which specimens of this species are often found; and it would require many figures to illustrate even a part of the forms and conditions in which the specimens are known to occur.

Position and locality. This is one of the most widely distributed of the Devonian corals, and it is likely to be found at various localities in Indiana, where Devonian strata are exposed.

Genus ZAPHRENTIS, *Rafinesque.*

ZAPHRENTIS RAFINESQUII, *Edwards & Haime.*

Plate 45, *Figs.* 3, 4 *and* 5.

The original specimens of this species were obtained by Edwards & Haime from near Jeffersonville, Indiana, and taken to France for study and description, together with many other American forms. The following is a free translation of their description as published in their "Monographie des Polypiers Fossiles:"

Corallum long, irregularly bent and contorted, showing numerous well-marked transverse folds. Calyx circular, thin at its borders and very deep. Septal fossett rather narrow, situated at the curved side; principal rays thirty-two, very close together at nearly the whole of their free parts, somewhat strongly denticulated, and prolonged below to the center of the calyx; or they are slightly flexuous but not elevated there. The principal rays alternate with an equal number of less developed rays. Length sixty or eighty millimeters; diameter of calyx 20 mm.; depth of calyx about 20 mm.

The three figures on plate 45 represent some of the various shapes in which specimens of this species occur, and will serve to give an approximate idea of its general aspect. It is probable that the figures 3 and 4 on plate V, of the report for last year represent a short example of this species; but the septal fossett in that case is upon the side of the convex curve of the corallum, instead of the concave.

Position and locality. Devonian strata near Jeffersonville, and other Indiana localities.

Genus AMPLEXUS *Sowerby.*

AMPLEXUS YANDELLI, *Edwards & Haime.*

Plate 45, *Figs.* 1 *and* 2.

Figures 1 and 2 on plate 45 represent somewhat satisfactorily the general characteristics of *Amplexus yandelli;* the former figure showing the outer aspect of the corallum, and the latter a longitudinal section of the same, exhibiting the broad transverse plates or tabulæ. A portion of the details of the structure are not clearly shown by figure 2, but together, and in connection with the following description as given by Dr. Nicholson, the species may be readily identified:

"Corallum simple, cylindrical, straight or curved. Calice varying in diameter from half an inch up to an inch and a half. Epitheca marked with from forty-five to sixty-five strong and angular septal ridges, which in well preserved examples are crossed by fine encircling striæ, and a few remote and regular folds of growth. The septa do not extend more than from half a line to two lines from the wall, leaving the tabulæ exposed over a large central area. The tabulæ appear to be generally flat; and the septa have plain sides, and are alternately large and small."

Position and locality. This is another species of which the types were obtained by Edwards & Haime from the Devonian rocks near Jeffersonville, Indiana, and published in their Monographie des Polypiers Fossiles des Terrains Paleozoiques. It may be sought for at the various localities in the State where the Devonian rocks are known to occur.

Genus FAVOSITES, *Lamarck*.

FAVOSITES BASALTICA, *Goldfuss*.

Plate 54, *Fig.* 1.

Mr. Van Cleve probably had before him an example of the species which is generally known as *Favosites basaltica*, Goldfuss, when he drew figure 1, plate 54. At least this figure gives a very fair idea of the general outward aspect of that form. Much difference of opinion exists among paleontologists as to the identity and limits of this species, which it is not necessary for me to discuss here. The following is Mr. Billings' description of the species as he identified it from specimens collected from the Devonian rocks of Canada.

"Corallum forming convex, sub-spherical or pyriform masses; corallites variable in size, and either all of nearly an equal width in the same specimen, or with many very small ones interspersed between the larger; transverse diaphragms thin, flexuous or flat, complete or incomplete; mural pores usually in one series. The width of the tubes varies from less than one line to two lines. The specimens generally referred to this species have a pyriform or hemispherical shape, and small, well defined, polygonal curved tubes, with one row of pores, rarely two."

Position and locality. This is one of the characteristic species of the Devonian rocks, and it may be sought for in those portions of Indiana in which rocks of that age occur.

FAVOSITES POLYMORPHA, *Goldfuss.*

Plate 50, *Fig.* 2, *and Plate* 53, *Figs.* 1 *and* 2.

This, like the preceding species, is a characteristic American Devonian coral, which has been identified with the European species of that name. It is very variable in outward form, and considerable diversity of opinion has prevailed as to the true limits of the species.

The figures referred to on plates 50 and 53 give a very good idea of its general aspect. The following is a description of the species as given by Professor Nicholson in his report on the paleontology of Ontario, (1874) p. 50.

"Corallum submassive or dendroid, often dichotomously branched, or reticulated; diameter of branches varying from a little over a line to more than an inch. Corallites radiating in all directions from an imaginary axis, nearly at right angles, or obliquely, more or less contracted internally, and widening as they approach the surface. Diameter of the corallites from half to three-quarters of a line, in branches of half an inch across, often with smaller ones intercalated. Calyces in reality more or less polygonal, but often rendered circular by the thickening of their walls. Mural pores in single series.

" The above would stand as a general definition for a number of branching species of *Favosites* which some eminent paleontologists, such as Lonsdale, McCoy and Billings, regard as belonging to a single natural group; whilst other high authorities, as De Blainville and Milne, Edwards and Haime, distribute them among several species. My own view would coincide with the former of these, namely, that the forms in question should be regarded as belonging to a single very variable specific type, the *Favosites polymorpha* of Goldfuss."

Position and locality. The discovery of this species may be expected wherever the Devonian rocks are exposed within the limits of the State.

FAVOSITES POLYMORPHA var. DUBIA.

Plate 53, Fig. 3.

This variety, which some authors regard as a distinct species, is described by Prof. Nicholson as follows, on page 51 of his report on the Paleontology of Ontario, (1874):

"Corallum dendroid, branched; branches not coalescing and inosculating as they do in *F. reticulata;* few small calices being intercalated amongst the larger ones. The diameter of the larger calices is from half a line to two-thirds of a line. The calyces are more or less rounded, and their walls thick. The diameter of the branches is mostly from three to four lines.

"In some specimens, in place of there being a few minute coralites interspersed amongst a great number of larger-sized ones, the corallites are only moderately unequal, and the number of small ones is about equal to that of the larger ones."

Position and locality. This variety is likely to be found associated with the typical form.

FAVOSITES, ———?

Plate 54, Fig. 2.

Figure 2 on plate 54 represents a view of the flat under side of a sub-hemispherical mass of *Favosites*, probably *F. hemisphaerica*, which is a not uncommon species in the Devonian rocks of Southern Indiana.

Genus FISTULIPORA, *McCoy.*

FISTULIPORA CANADENSIS, *Billings.*

Plate 47, Figs. 1 and 2.

The following is Mr. Billings' description of this species, as given in the Canadian Journal, New Series, Vol. IV, p. 98:

"Corallum forming irregular, contorted masses, or wide, flat, undulating expansions or layers, from one-half of an inch to an inch in thickness, which are based upon a thin, concentrically wrinkled epitheca. Cell-tubes half a line or less in diameter, and about one line distant from each other; the mouths of the tubes protruding a little above the general surface. Transverse diaphragms thin, horizontal, or flexuous, and sometimes very numerous, there being in some of the tubes three or four in half a line of the length of a tube. The intercellular tubules are polygonal, and about four in the diameter of the principal cells; their transverse diaphragms are well developed, usually four or five to one line of the length."

Figure 1 represents the appearance of the upper surface of this species very satisfactorily; but the section of a corallum represented by figure 2 is much thicker than the corallum of the species that usually occurs. It also fails to show satisfactorily the small secondary tubules as separate from the principal corallites.

Position and locality. *Fistulipora canadensis* is a not uncommon fossil in the Hamilton group of New York and Canada, and it is abundant in the Devonian strata of Indiana.

Genus ALVEOLITES.

ALVEOLITES GOLDFUSSI, *Billings*.

Plate 54, *Fig.* 3.

This figure was evidently drawn from an example of *Alveolites goldfussi*, Billings. Usually, the mouths of the corallites are somewhat larger in this species than they are represented in the figure, but they are sometimes as small as they are there represented. The following is Professor Nicholson's description of the species, as given in his report on the paleontology of Ontario, (1874) p. 56:

"Corallum forming irregular, undulated expansions, or depressed, discoidal masses, several inches in width, and from two lines up to two inches in thickness. Under surface covered with a thin, concentrically wrinkled epitheca, similar in every respect to that of a *Favosites*. The epitheca carries in young examples one, and in aged examples many, layers of corallites, which are arranged in a radiating manner around the central part of the coral, and which open very obliquely upon the surface. The calyces are of large size, in general from three-fourths of a line to one line across and half a line in height. Their shape is usually transversely oval, or three sided, the outer side being curved, and the two inner sides straight. Owing to the thinness of the walls of the corallites, the calyces do not appear to be separated by any interspaces transversely, but overlap one another. There are no traces of teeth or grooves on the interior of the corallite."

Position and locality. Specimens of this form have been found in the Devonian rocks of Canada and the State of New York, and I have collected from rocks of the same age in Iowa some examples which I believe to belong to the same species; and is found in the counties of Clark, Decatur, Bartholomew, Shelby, Delaware, Cass, etc.

Genus STRIATOPORA, *Hall.*

STRIATOPORA LINNÆANA, *Billings.*

Plate 47, *Fig.* 7.

Although figure 7, on plate 47, is unsatisfactory as to some of the details of structure, it was doubtless drawn from a portion of a large corallum of *Striatopora linnæana.* The following is Mr. Billings' description of this species as given in the Canadian Journal, new series, Vol. V, p. 253:

"Stems two or three lines in diameter, branching at an angle of 75° to 80°; cells variable in size, the greater number with the expanded mouth one line wide, and the circular cavity at the bottom from one-third to one-half of a line; the smaller or younger cells of all sizes are somewhat uniformly distributed among the larger. In the perfect specimens the mouths of the cells are everywhere in contact with each other, the edges of the walls between them sharp, and the form more or less polygonal, generally five or six sided. In worn specimens the cells are more nearly circular, and the walls obtusely rounded on the edge. The striæ in the cell-mouths not observed."

Position and locality. The original examples were obtained from the strata of the Hamilton group in Canada. It occurs in the Devonian strata of Indiana.

Genus SYRINGOPORA, *Goldfuss.*

SYRINGOPORA PERELEGANS, *Billings.*

Plate 49, *Fig.* 3.

"Corallites one line in diameter, sometimes a little more or less, distant a little less than one line; connecting tubes half a line in diameter, and distant from one line to one line and a half, usually projecting at right angles, but sometimes a little oblique. Epitheca with numerous annulations, generally indistinct, but under certain circumstances of growth sharply defined and deep, so much so as to give to the corallites the appearance of the jointed stalk of a crinoid. The young individuals are produced by lateral budding, and on one specimen the whole colony appears to be based upon a broad lamellar foot-secretion like that which forms the base of a Favosite.

"The distance of the corallites is usually about a line, but like all other species this one varies a good deal in this respect. When some cause has intervened to prevent their regular growth, they are much flexed and consequently at times more distant than when they have been undisturbed. The connecting tubes on the same side of the corallite, are three or four lines distant, but generally on the other sides one or two others in the same space occur, making the average distance one line, or one line and a half."

This species is very closely allied with *Syringopora reticulata* Goldfuss, from the Carboniferous of Europe. It appears to differ only in having proportionally fewer connecting processes.

Position and locality. Originally from the Corniferous limestone of Canada. It is found in the Devonian rocks of Indiana.

SYRINGOPORA MACLUREI, *Billings.*

Plate 47, Fig. 3.

The figure prepared by Mr. Van Cleve seems to agree well with Mr. Billings' description of *Syringopora maclurei*, but Mr. Van Cleve referred it to *S. ramulosa* of Goldfuss. The species represented by this figure is probably not identical with that European species, and it also may not belong to *S. maclurei*, but I am acquainted with no described American form with which the figure more nearly agrees. The following is a copy of Mr. Billings' description, Canadian Journal, N. Ser., Vol. IV, p. 115.

"This species is found in large masses of long, slightly flexuous corallites. These have a diameter of about a line and a half, and, owing to their flexuosity, are at times in contact, and often two or three or four lines apart. In large colonies, which have grown luxuriantly without the interference of disturbing causes, the corallites are more regular than in the smaller or stunted groups, in which the corallites are much bent and confused. The connecting processes are very short and distant, and appear to be sometimes mere inosculations of the stems. The corallites, after growing separately for a short distance, approach each other and seem to grow together or adhere to each other for the space of a line and a half, or more, they then diverge and again unite. These points of contact occur at distances varying from three lines to six, nine or even twelve lines. Externally they exhibit numerous other indistinct annulations, and also faint indications of longitudinal striæ."

Position and locality. Mr. Billings states that *S. maclurei* is abundant in the Corniferous limestone of Canada West; and is found in the Devonian rocks of Indiana.

Genus STROMATOPORA, *Blainville.*

STROMATOPORA PUSTULIFERA, *Winchell?*

Plate 53, Figs. 4 and 5.

These figures appear to represent the species which Professor Winchell described in the appendix to his report on the Grand Traverse Region of Michigan, under the name of *Stromatopora pustulifera.* It may, however, prove to be a different species, as the pustules represented by the figure are considerably larger than those of Prof. Winchell's type specimens, and yet not so large as those of his *S. monticulifera.* The following is his description of the first named species:

"In very large spheroidal, ovoid or elongate masses, composed of arching, transverse layers, formed of laminæ of coralline substance separated by a network of minute passages which, at intervals, coalesce and turn upward through the layer, radiating and ramifying again on the upper side. The places where the layers are thus traversed are raised on the upper side into little eminences. The distinction of layers is produced by variations in the density of the coralline substance. Masses of coral several feet in diameter."

Position and locality. The species described by Professor Winchell, under the name of *S. pustulifera* is somewhat common in the Devonian rocks of Michigan and Iowa, and is likely to occur in strata of that age in Indiana.

SUBCARBONIFEROUS.

Genus LITHOSTROTION, *Fleming*.

LITHOSTROTION MAMILLARE, *Castelnau*.

Plate 52, *Fig*. 3.

Mr. Van Cleve's figure is a very good representation of the upper surface of a corallite of this species, showing the calyces and the elevation at the bottom of each. It is a characteristic fossil of the St. Louis division of the Subcarboniferous series; but as it was described on page 506, (138) of the report for last year, its repetition is not necessary here.

The following letter from Dr. Julius S. Taylor to Professor Collett, gives a few of the leading facts of the life of the author of the illustrations of the fossil corals which are described on the preceding pages.

KANKAKEE, ILL., June 8, 1881.

Prof. John Collett, State Geologist of Indiana:

DEAR SIR:—The engraved plates of geological specimens which I have loaned to you for publication in the Indiana State reports were the production of my friend, the late John W. Van Cleve, Esq., who drew and engraved them to accompany a work on fossil corals which he had prepared for publication, but died before accomplishing it.

Mr. Van Cleve was born in Dayton, Ohio, June 27, 1801, and lived in that city continuously until his death, which occurred September 6, 1858. He was a man of sterling integrity and marked ability, and was greatly honored and respected by his fellow-citizens for the excellencies of his character and his liberal public spirit.

I had the good fortune to become acquainted with him in 1838, and to enjoy his intimate friendship until his death. He was an ardent student of geology, and much of our intimacy consisted in our joint study of this absorbing science. His acquirements were such in that study, that if he had been ambitious of distinction, he might have stood in the foremost rank of the geologists of that day; but he was naturally of a retiring disposition, and, above all, he disliked mere notoriety. In everything he did he was careful and thorough, and in addition to his ability as a geologist, he possessed such skill as an artist and engraver, that he was able to delineate the objects he studied with great truthfulness.

After the death of Mr. Van Cleve, his nephew, Mr. Thomas Dover, presented me with these plates, because of my long friendship with his uncle; and I am especially glad that an opportunity has at last occurred to do honor to the friend I loved so well, by having at least a portion of the work published upon which he bestowed such long and patient labor.

Your friend,

JULIUS S. TAYLOR.

ERRATA.

Page 8, Line 1—For *germs* read gems.
Page 112, Second Line from top—Range 8 should be range 9.
Page 139, Sixth Line from the bottom—"*clearage*" should read cleavage.
Page 142, Line 33—For *trix* read strix.
Page 151, Line 3—For *west* read east.
Page 176, Line 31—For *members* read numbers.
Page 180, Line 7—For *their* read thin.
Page 181, Line 6—Insert comma after place.
Page 192, Line 30—For *Deitricks* read Beitricks.
Page 199, Line 1—For *Noble* read Nolte.
Page 210, Line 30—For *are* read is.
Page 254, Line 19—For *fifteen* to *twenty-five* read .15 to .25.
Page 273, Line 33—For *aduntant* read abundant.
Page 277, Line 18—For *unknown* read unworn.
Page 277, Line 20—For 17 read 19.
Page 286, Line 33—For *liule* read line.
Page 316, Line 14—For 28 read 27.
Page 333, Line 20—For *occur* read occurs.

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EXPLANATION OF PLATES.

PLATE 1.

DENDROGRAPTUS (CHAUNOGRAPTUS) NOVELLUS, *Hall.*

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Fig. 1. A frond attached to a fragment of *Eucalyptocrinus*, enlarged four diameters.
Fig. 2. A valve of *Spirifera radiata*, covered with numerous fragments of fronds—natural size.

INOCAULIS DIVARICATA, *Hall.*

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Fig. 3. A frond, natural size, showing the form, structure, and divergence of the branches.

ASTYLOSPONGIA (PALÆOMANON) BURSA, *Hall.*

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Fig. 4. A portion six times enlarged showing the stelliform spiculæ and punctate surface.

RECEPTACULITES SACCULUS, *Hall.*

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Fig. 5. View of a specimen broken longitudinally through the middle.

BUTHROTREPHIS GRACILIS, var. CRASSA, *Hall.*

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Fig. 6. A small frond of this species as preserved in the soft shale.

STREPTELASMA (DUNCANELLA) BOREALIS, *Nicholson.*

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Fig. 7. A longitudinal section showing the cylindrical cavity in the center of the corallum, and the lamellæ with their finely serrate margins.
Figs. 8, 9, 10. Transverse sections through the apex, middle and base of the cups respectively.

FAVOSITES FORBESI, var. OCCIDENTALIS, *Hall.*

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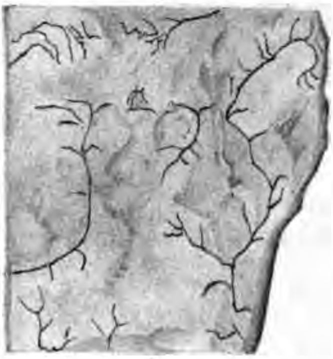
Fig. 11. A specimen preserving the opercula to the cell-apertures, showing their concentric ornamentation.
Fig. 12. A small incipient colony attached to the dorsal valve of *Meristina nitida*.
Fig. 13. A small specimen showing very elongate cell-tubes and greatly developed epitheca. The open cell-apertures are only at the summit.
Fig. 14. A pyriform individual covered with an epitheca in the lower part.

NIAGARA GROUP

1



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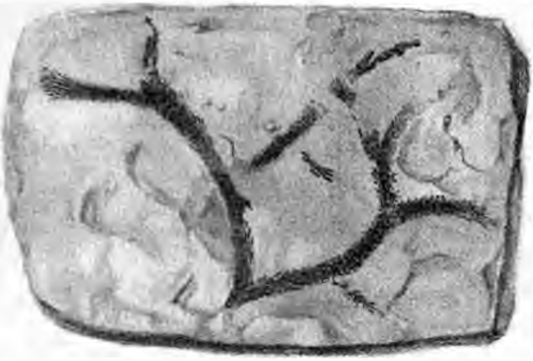

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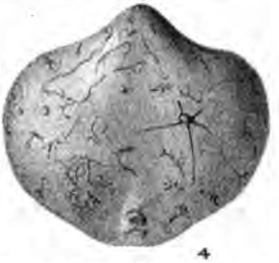

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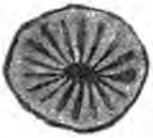

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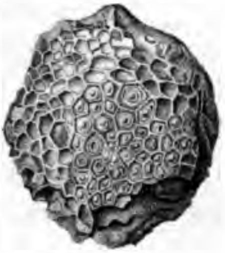

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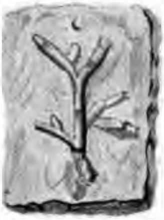

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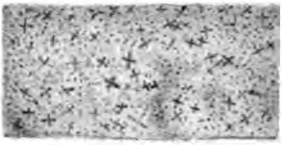

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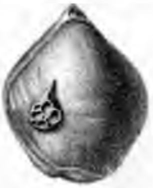

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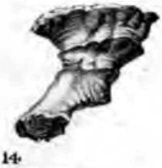

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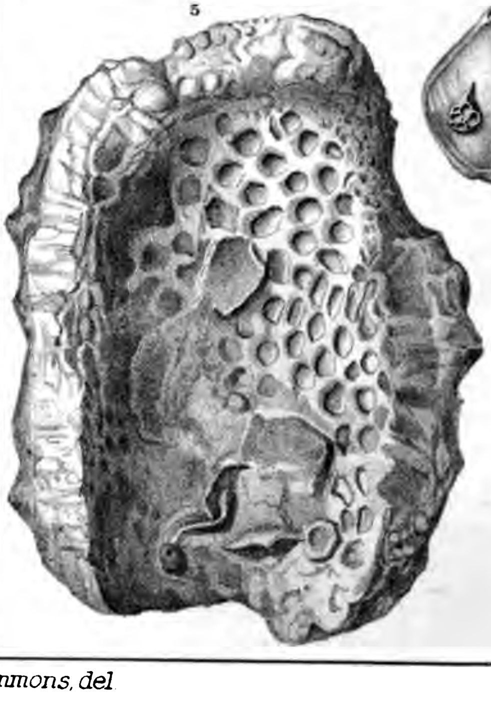

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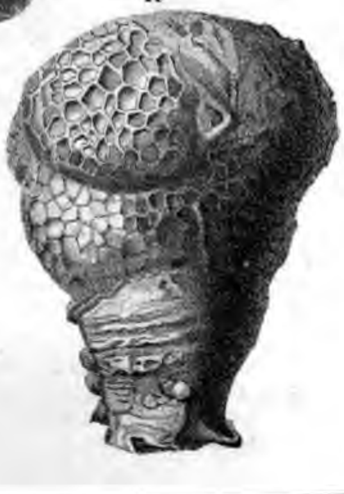

Emmons, del

Wm.B Burford, Lith. Indianapoli

PLATE 2.

RECEPTACULITES SUBTURBINATUS, *Hall.*

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Fig. 1. Lateral view of a specimen enlarged to two diameters.
Fig. 2. A further enlargement of the surface, showing the form of the cells.
Fig. 3. An enlarged summit view of another specimen.

ASTYLOSPONGIA PRÆMORSA, *Goldfuss.*

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Figs. 4, 5. Lateral and summit views of a specimen of medium size.
Fig. 6. View of the upper side of a more deeply lobed specimen.
Figs. 7, 8. Upper and lateral views of a very perfectly formed specimen, enlarged two diameters.
Figs. 9, 11. Vertical sections of two specimens showing structure, enlarged to two diameters. The dark spots in the center are filled with pyritous matter, and are not cavities.
Fig. 10. Horizontal section of another specimen, enlarged two diameters.
Fig. 14. A crushed and imperfect specimen, showing the radiating fibrous-like character of the substance (enlarged).

ASTYLOSPONGIA PRÆMORSA, *var.* NUXMOSCHATA, *Hall.*

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Figs. 12, 13. Lateral and summit views of a specimen, showing the difference in the form and lobation of the surface from typical *A. præmorsa.*

ASTYLOSPONGIA (PALÆOMANON) BURSA, *Hall.*

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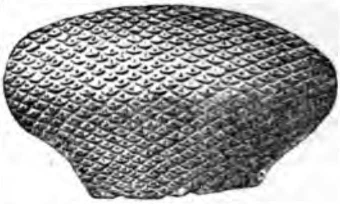
Figs. 15, 16. Lateral and profile views of a crushed specimen, showing the characters of the species.

1



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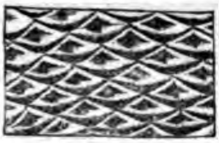

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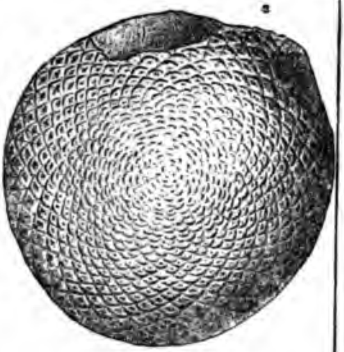

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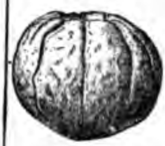

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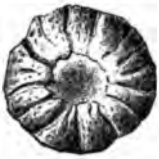

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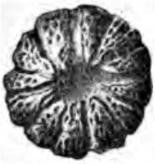

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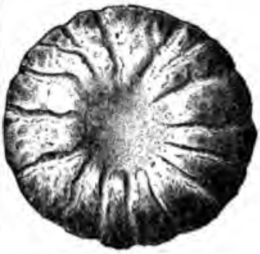

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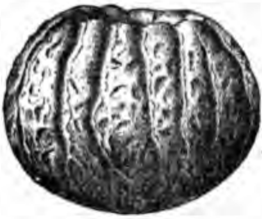

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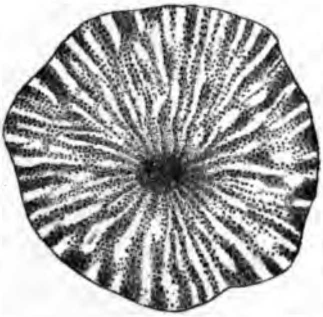

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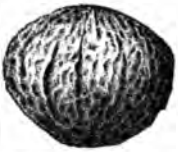

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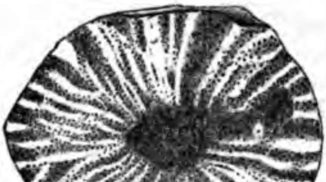

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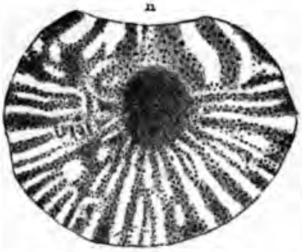

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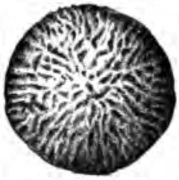

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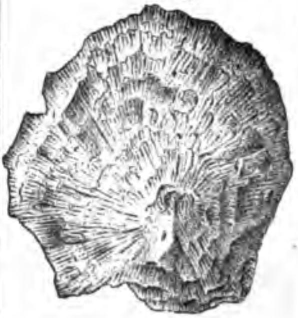

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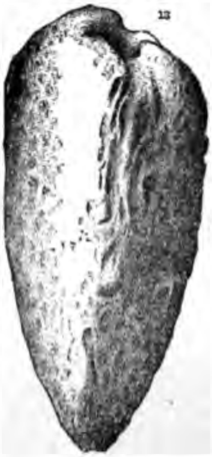

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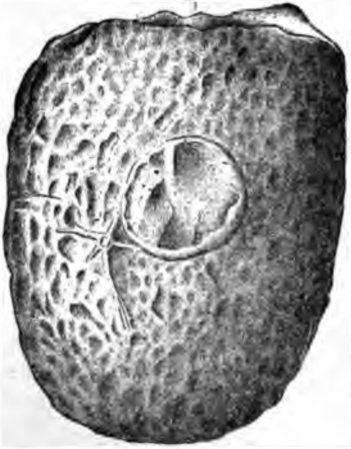

PLATE 3.

FAVOSITES SPINIGERUS, *Hall.*

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Figs. 1, 2. Upper and lateral views of a specimen of the usual character.

Fig. 3. Vertical section of a similar specimen, showing the divergence of the cells and the distant entire diaphragms.

Fig. 4. Vertical section of a specimen with larger cells.

Fig. 5. An enlarged oblique view of a portion of the surface, showing the irregular cells and the spiniform projection at the angles.

FAVOSITES FORBESI, *var.* OCCIDENTALIS, *Hall.*

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Fig. 6. An irregular hemispherical specimen, showing small cells with a few of somewhat larger size.

Figs. 7, 8. Turbinate forms with large irregular cells, the lower part covered by the epitheca.

Fig. 9. The upper side of a large irregular specimen.

Fig. 10. Lateral view of a large broadly turbinate specimen, having the lower part covered by the epitheca and showing in the upper part an irregular distribution of large and small angular cells.

Fig. 11. A vertical section of a specimen similar to fig. 8, showing the closely arranged diaphragms.

Fig. 12. An enlarged transverse section, showing the thick vertical walls.

Fig. 13. Enlarged vertical section showing the thick walls and large mural pores.

Fig. 14. The natural surface of a well-preserved specimen, showing the granulations upon the diaphragms.

Fig. 15. An oblique view of the same. In the figure the vertical walls are not sufficiently elevated above the diaphragms.

NIAGARA GROUP.

PLATE 3.

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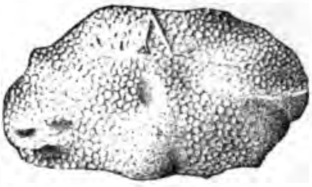

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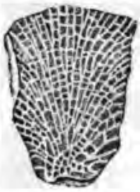

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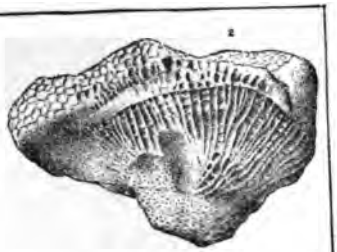

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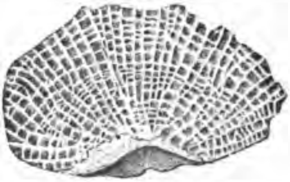

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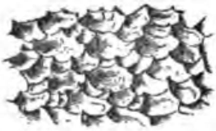

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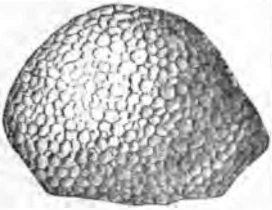

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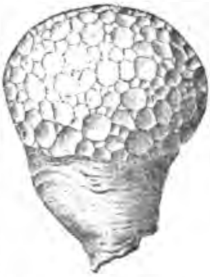

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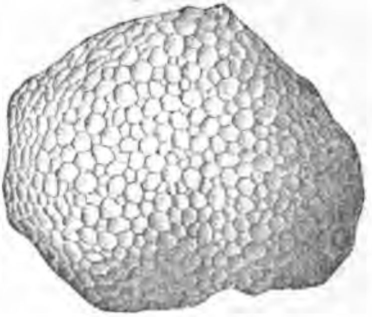

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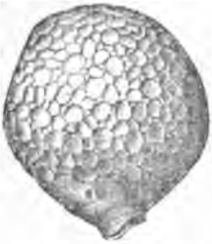

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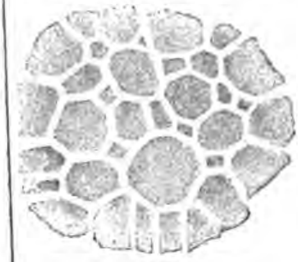

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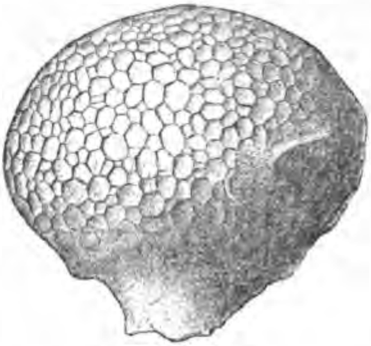

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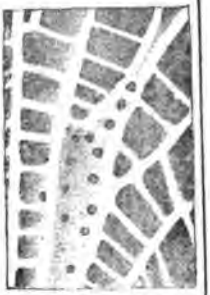

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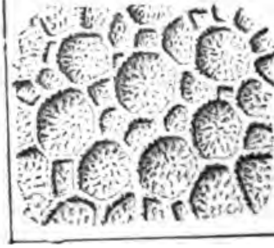

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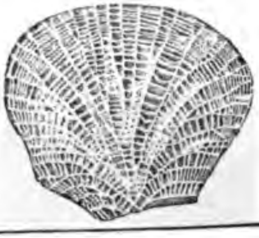

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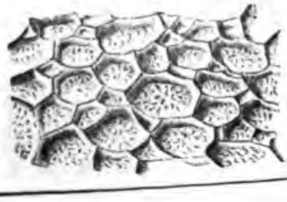

PLATE 4.

STREPTELASMA RADICANS, *Hall*.

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Figs. 1, 2. Dorsal and ventral views of an imperfect specimen, showing the spreading root-like base.

Fig. 3. Lateral view of a similar specimen.

Fig. 4. An enlarged longitudinal section, showing the depth of the cup and the character of the lamellæ. The continuation of the lower part from the horizontal line is incorrectly represented, the lamellæ becoming obsolete and solid at a short distance below.

ZAPHRENTIS CELATOR, *Hall*.

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Figs. 5, 6. Lateral and posterior views of a specimen showing the form of the cup.

STREPTELASMA (DUNCANELLA) BOREALIS, *Nicholson*.

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Fig. 7. A fragment of rock showing two individuals of this species.

Fig. 8. An enlargement of one of the above to show the form and character of the exterior.

LICHENALIA CONCENTRICA, *Hall*.

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Fig. 9. A small irregularly growing specimen.

Fig. 10. Another irregular specimen—the frond being enrolled upon itself.

Fig. 11. Section of the specimen fig. 10, showing the great increase in length of the cells on the enrolled portion.

Fig. 12. The celluliferous surface of a large irregular specimen which has encrusted other bodies, and in places shows a tendency to form tubular extensions and branches.

Fig. 13. An enlargement from the surface of the specimen fig. 9, showing the form and arrangement of cells.

Fig. 14. An enlargement from the surface of fig. 12, showing angular (subtriangular) cell-apertures. This character is shown only on a part of the surface, the other portions having oval or circular apertures.

Fig. 15. Enlargement from a specimen similar to fig. 13, but with larger cells.

Fig. 16. A portion of *Strophostylus cyclostomus*, bearing four young specimens of Lichenalia and the base of a Cornulites; the entire surface of the shell below being covered by another Bryozoan (*Paleschara*.)

Fig. 17. A young frond growing upon the surface of *Platyostoma Niagarense*.

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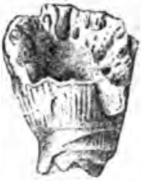

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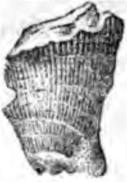

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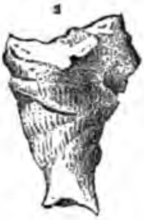

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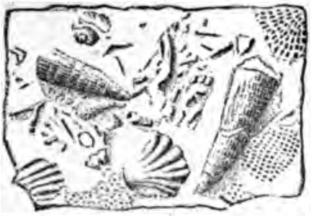

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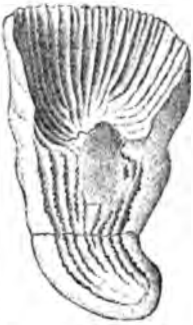

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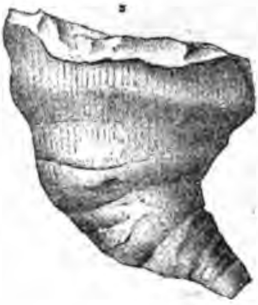

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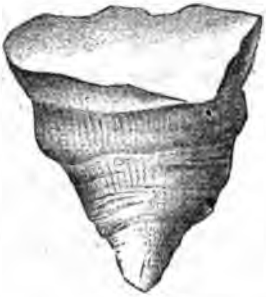

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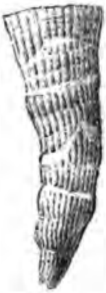

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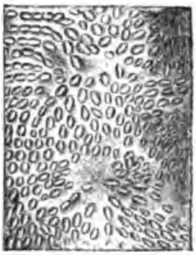

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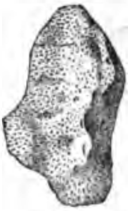

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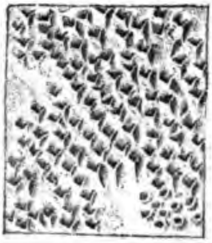

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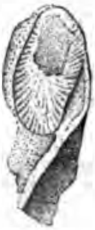

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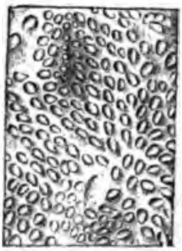

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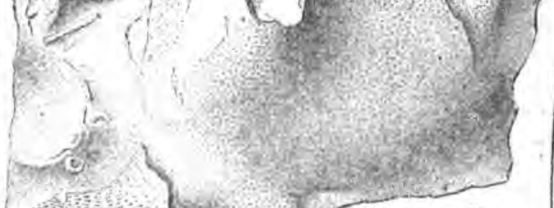

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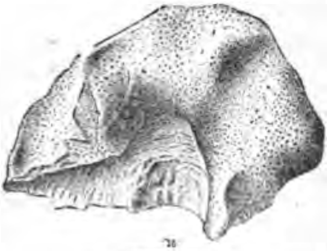

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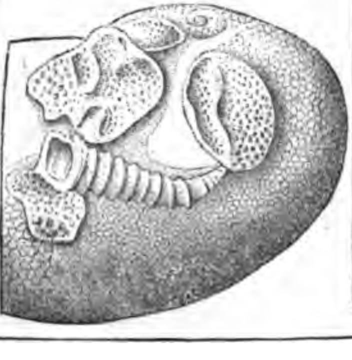

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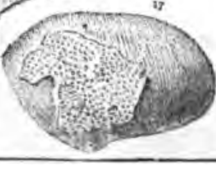

PLATE 5.

Lichenalia concentrica, *Hall.*

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Figs. 1, 2. The upper and lower surface of a young specimen, the latter showing a small cicatrice of attachment.

Fig. 4. The under surface of a specimen, showing the epitheca in its irregular growth, and its strong concentric markings.

Fig. 7. A fragment of Fenestella, having two young specimens of Lichenalia attached to the surface.

Fig. 8. The lower surface of a small fragment with scarcely any remaining epitheca, and so translucent that the structure is visible through the substance, showing the elongated cell-bases.

Fig. 9. The lower surface of a specimen corresponding to fig. 3, showing the concentric markings of the epitheca.

Fig. 10. The lower surface of a small specimen where the epitheca has been worn away or only partially developed, showing along the base, the radiating grooves formed by the cells before curving upward toward the surface.

Lichenalia concentrica, *var.* maculata, *Hall.*

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Fig. 3. The upper or celluliferous surface of a regularly growing specimen of medium size, showing tubercles with maculæ of larger cells. The cells are represented much larger than they really are on the specimen. (See fig. 5.)

Fig. 5. A small irregular specimen, with unusually distinct maculæ upon the celluliferous surface.

Fig. 6. An enlargement from a part of the surface of specimen fig. 3, where it has been worn or macerated, showing the angular intercellular spaces.

NIAGARA GROUP.

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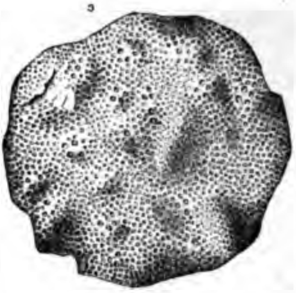

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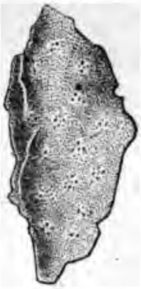

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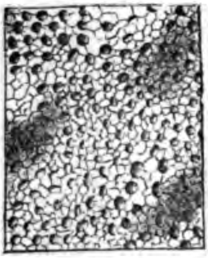

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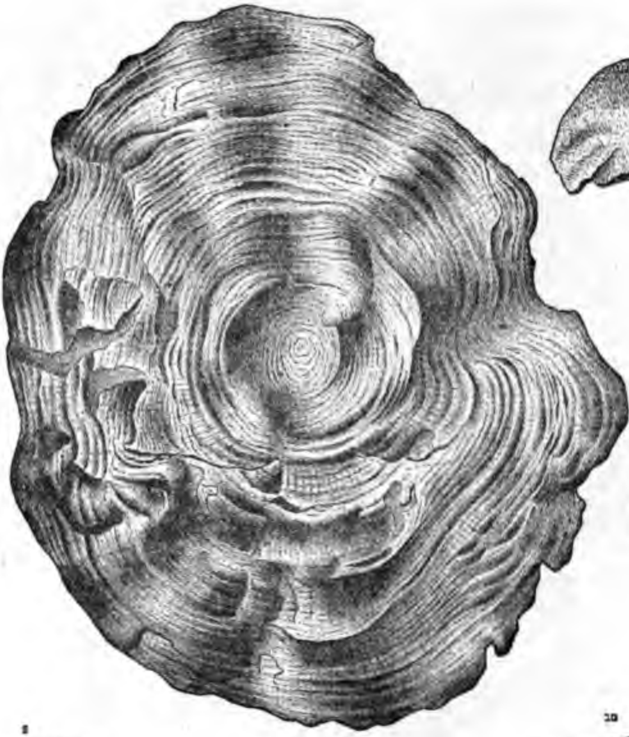

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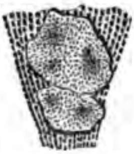

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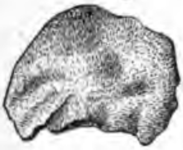

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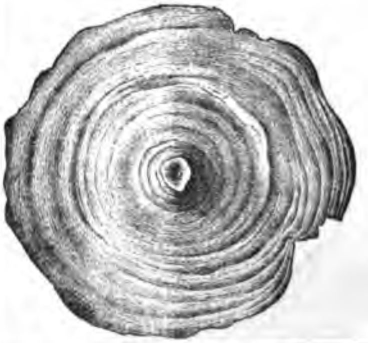

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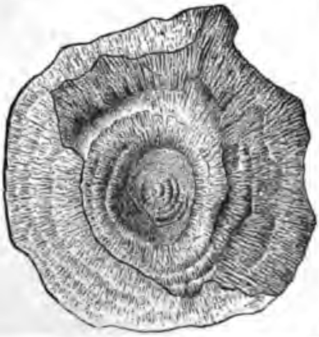

PLATE 6.

LICHENALIA CONCENTRICA, *var.* PARVULA, *Hall.*

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Fig. 1. A fragment of this form of Lichenalia which has grown upon the upper surface of a Strophostylus.

Fig. 2. An enlargement of a portion of the above, showing the cells to be much smaller and more distinctly circular than in the ordinary form of *L. concentrica.*

LICHENALIA CONCENTRICA, *Hall.*

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Fig. 3 An enlargement of a young Lichenalia, showing it as it has grown attached to the surface of an Atrypa.

Figs. 4, 5, 7, 8. Enlargements from the surfaces of Lichenaliæ as presented in different individuals. Figures 4 and 5 are respectively three and four diameters of the young specimens attached to Fenestella. (See pl. 11, fig. 3.)

Fig. 6. An enlargement of about four diameters of a group of two young Lichenaliæ and a young Favosites, attached to the shell of Strophostylus.

Figs. 9, 10. Enlargements from the lower surfaces of different individuals, showing the variable conditions of the epitheca. In fig. 9 the cell-partitions are shown through the texture; and fig. 10 presents a fibrous condition, from the removal of the epithecal covering leaving the projecting cell-walls.

Fig. 11. An enlarged transverse section of a specimen similar to fig. 4 of plate 5, showing the depth of the cells and the thickness of the epitheca in old individuals.

The variations in expression, in the many forms of this species, the size, proportion and arrangement of the cellules upon the surface, and the aspects produced by weathering or maceration are so great as often to induce a reference to distinct species. It does not, however, seem possible to convey in a satisfactory manner, the characters as they appear to the eye and under the lens.

SAGENELLA ELEGANS, *Hall.*

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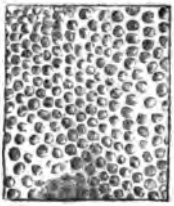
Fig. 12. The left valve of *Ambonychia acutirostra*, showing the encrusting membraneous bryozoan upon its surface.

Fig. 13. An enlargement of a portion of the same specimen to show the tubular cells and their apertures.

NIAGARA GROUP.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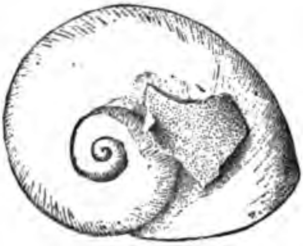
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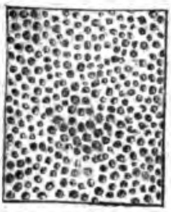
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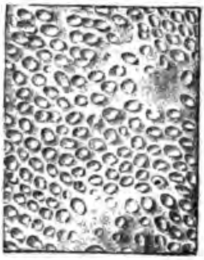
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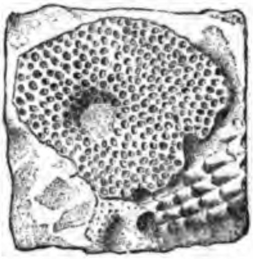
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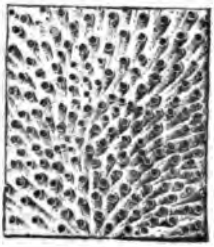
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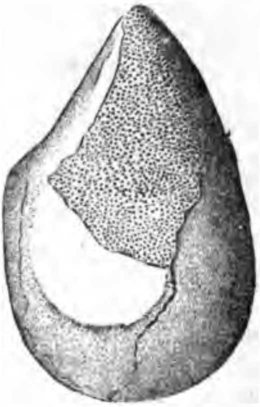
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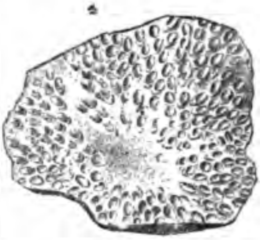
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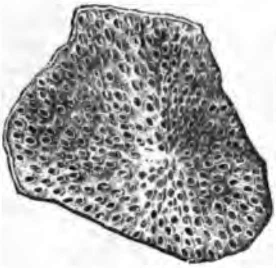
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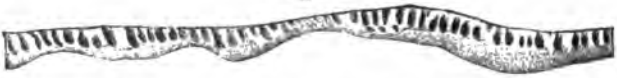
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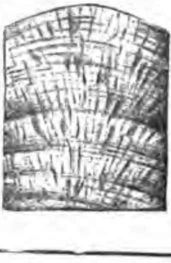
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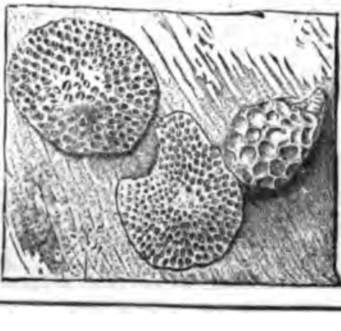
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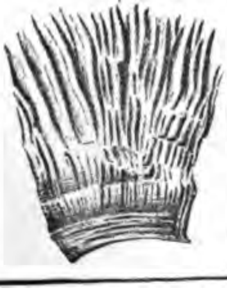
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PLATE 7.

CERAMOPORA LABECULA, *Hall.*

Page 242.

Fig. 1. A small colony of the bryozoan, attached to the surface of a Fenestella, just showing distinct rounded tubular cells: enlarged to six diameters. In the figure, the cells are a little too distinctly individualized.

Fig. 2. A fragment of Fenestella upon which are two separate colonies of the species, enlarged to the same degree as in the preceding figure.

Fig. 3. Another and larger separate colony enlarged to the same degree. This and the colony in fig. 2. show the ordinary form of cells pertaining to the species.

CERAMOPORA CONFLUENS, *Hall.*

Page 243.

Fig. 4. The bryozoan entirely encrusting a specimen of *Platyostoma Niagarense.*

Fig. 5. An enlargement to show the character of the cells and the centers of radiation forming tubercles. The cells radiate a little more distinctly from these centers than is apparent in the figure.

CERAMOPORA AGELLUS, *Hall.*

Page 243.

Fig. 6. A colony attached to the surface of *Strophostylus cyclostomus.* The cells are largest at the initial point near the lower end, and gradually decrease toward the margin, where they are exceedingly minute. Enlarged to four diameters.

PALESCHARA OFFULA, *Hall.*

Page 245.

Fig. 7. A fragment (natural size), encrusting some foreign substance.

Fig. 8. An enlargement of a portion of the surface to six diameters, showing the character of the cells.

PALESCHARA MACULATA, *Hall.*

Page 246.

Fig. 9. A specimen (natural size), encrusting some foreign cylindrical body.

Fig. 10. An enlargement of the surface to the same degree as fig. 8, and presenting also, near the center of the figure, one of the maculæ of larger cells.

Fig. 11. A specimen of Platyostoma having the surface covered by the substance of the bryozoan.

NIAGARA GROUP.

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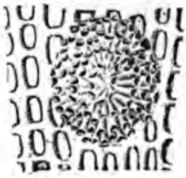

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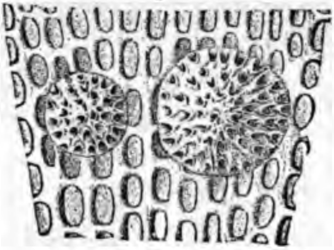

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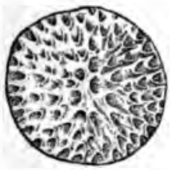

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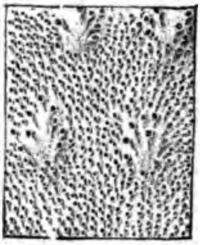

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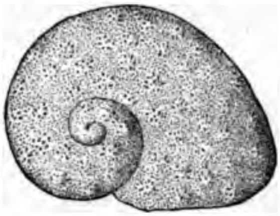

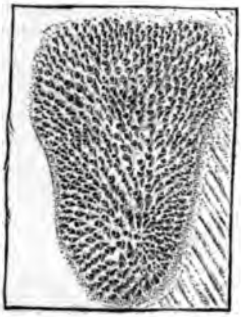

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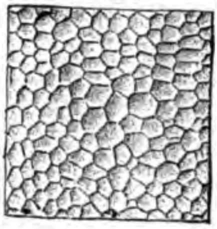

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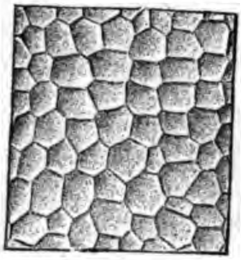

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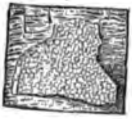

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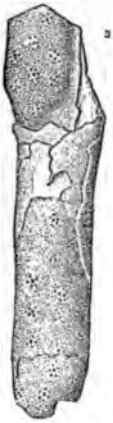

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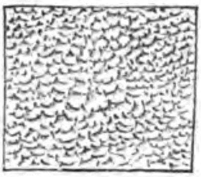

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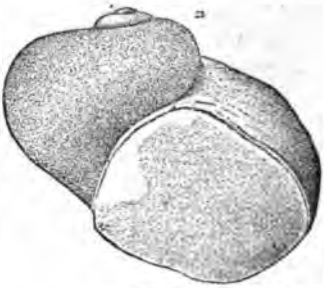

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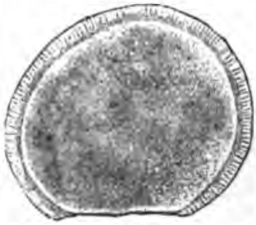

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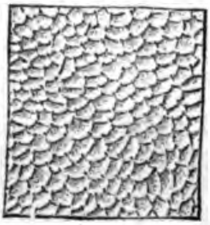

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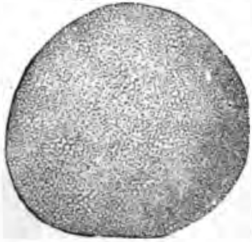

PLATE 7—Continued.

Fig. 12. An oblique lateral view of a portion of the surface, showing the asperities at the angles of the cells. Enlarged to six diameters.

Fig. 13. An enlarged view of the same, looking directly upon the cell-apertures.

PALESCHARA? (CHÆTETES?) SPHÆRION, *Hall.*

Page 247.

Fig. 14. View of one side of the colony, enlarged to two diameters, showing the arrangement of the cells.

Fig. 15. A section through the center of the specimen, enlarged to the same degree as fig. 14. The dark line at the base of the cell represents the solid substance of the cell floor, the inner space being filled with inorganic calcareous clay.

PLATE 8.

FAVOSITES SPINIGERUS, *Hall*.

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Fig. 1. The upper surface of a specimen, the cells of which are smaller than those of the specimen represented on plate 3, and without the processes at the angles of the cells.

Fig. 2. An enlargement to four diameters of a portion of the surface.

CALLOPORA EXSUL, *Hall*.

Page 238.

Fig. 3. The upper side of a specimen (natural size).

Fig. 4. An enlargement of the cell apertures. The original of this figure is a specimen of CALLOPORA incrusting and partially covering CERAMOPORA, and the form of the cell-apertures represents the latter genus while the denticulate margins are of CALLOPORA.

AULOPORA PRECIUS, *Hall*.

Page 227.

Fig. 5. A colony attached to the surface of *Meristina nitida*.

Fig. 6. Enlargement from the preceding specimen, showing the form and character of the cells.

CHÆTETES CONSIMILIS, *Hall*.

Page 230.

Figs. 7, 8. A specimen, natural size, and an enlargement to five diameters from the lower bifurcation, where the tubes have grown so as to leave the cell-walls exposed.

Figs. 9, 10. A specimen, natural size, and an enlargement from the lower end, showing the solid stem with columnar structure, and angular cell-apertures.

Figs. 11, 12. Another individual, and an enlargement from the lower bifurcation, showing the young cells in the angles of the larger ones.

Figs. 13, 14. Another individual and an enlargement of the same, where the cell-walls are flattened on the surface, as from wearing. All the enlargements are to five diameters.

NIAGARA GROUP.

PLATE 8.

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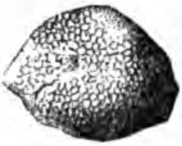

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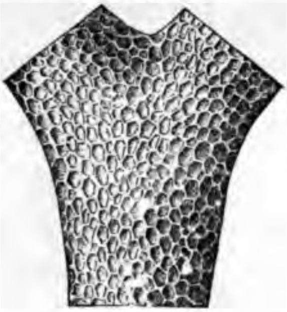

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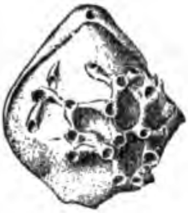

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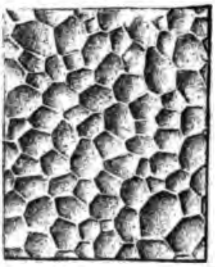

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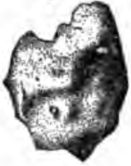

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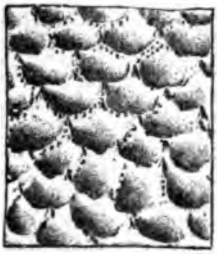

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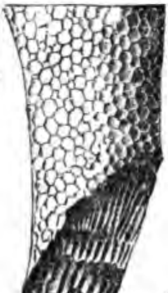

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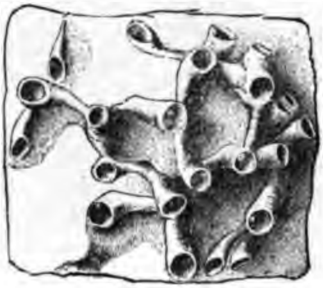

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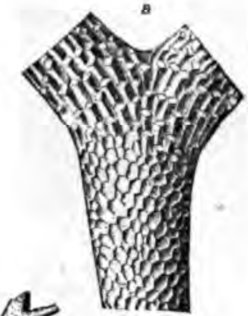

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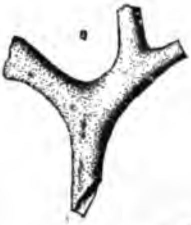

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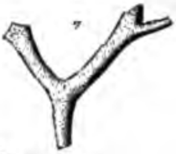

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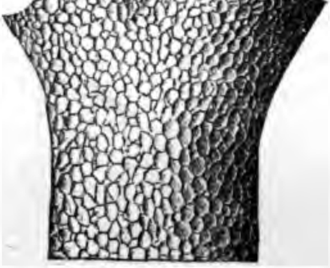

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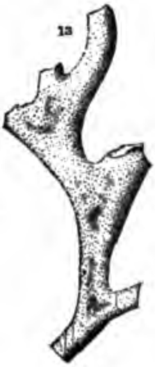

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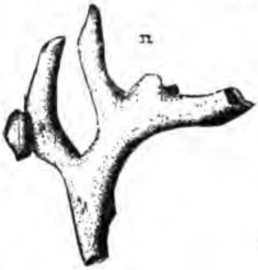

PLATE 9.

CALLOPORA SINGULARIS, *Hall.*

Page 237.

Figs. 1, 2. A specimen, natural size, and an enlargement, showing the arrangement of the cells. The interstices of the intercellular spaces as represented are too small and indistinct.

TREMATOPORA INFREQUENS, *Hall.*

Page 232.

Fig. 3. A fragment of shale, with a group of stems, of which one specimen is of this species. Natural size.

Fig. 4. Enlargement of a bifurcation from the individual on the right hand side of the specimen fig. 3.

TREMATOPORA OSCULUM, *Hall.*

Page 231.

Figs. 5, 6. A specimen, natural size, and enlarged, showing cells of smaller size than the preceding species.

Figs. 7, 8. A specimen, natural size, and enlarged, showing the cell-apertures more crowded and more exsert than in the last.

Figs. 11, 12. A specimen which appears to have been tubular, with scattered pores. The enlargement, fig. 12, does not fully represent the object.

Fig. 13. A specimen, natural size.

Fig. 14. The same enlarged.

TREMATOPORA SUBIMBRICATA, *Hall.*

Page 234.

Figs. 9, 10. A specimen showing arrangement of the cells opening obliquely upward, and the upper margin not elevated.

TREMATOPORA VARIA, *Hall.*

Page 232.

Figs. 15, 16. A specimen, natural size and enlarged. The cell-apertures appear to have been worn or dissolved away, giving the appearance of double cell walls. Enlargement eight diameters.

Figs. 17, 18. Another individual showing the apertures reduced in size by the contracted margins. Enlargement about six diameters.

Figs. 19, 20. A specimen in which the cells are irregular in size, some of them with elevated margins and others without.

Figs. 21, 22. A thickened branching form, with the branches flattened above, and showing other variations in the form and size of cells. This and the preceding enlargement are four diameters each.

Fig. 23. Transverse section of the lower part of the specimen fig. 21, showing a hollow tube, and the mode of growth of the cells.

NIAGARA GROUP.

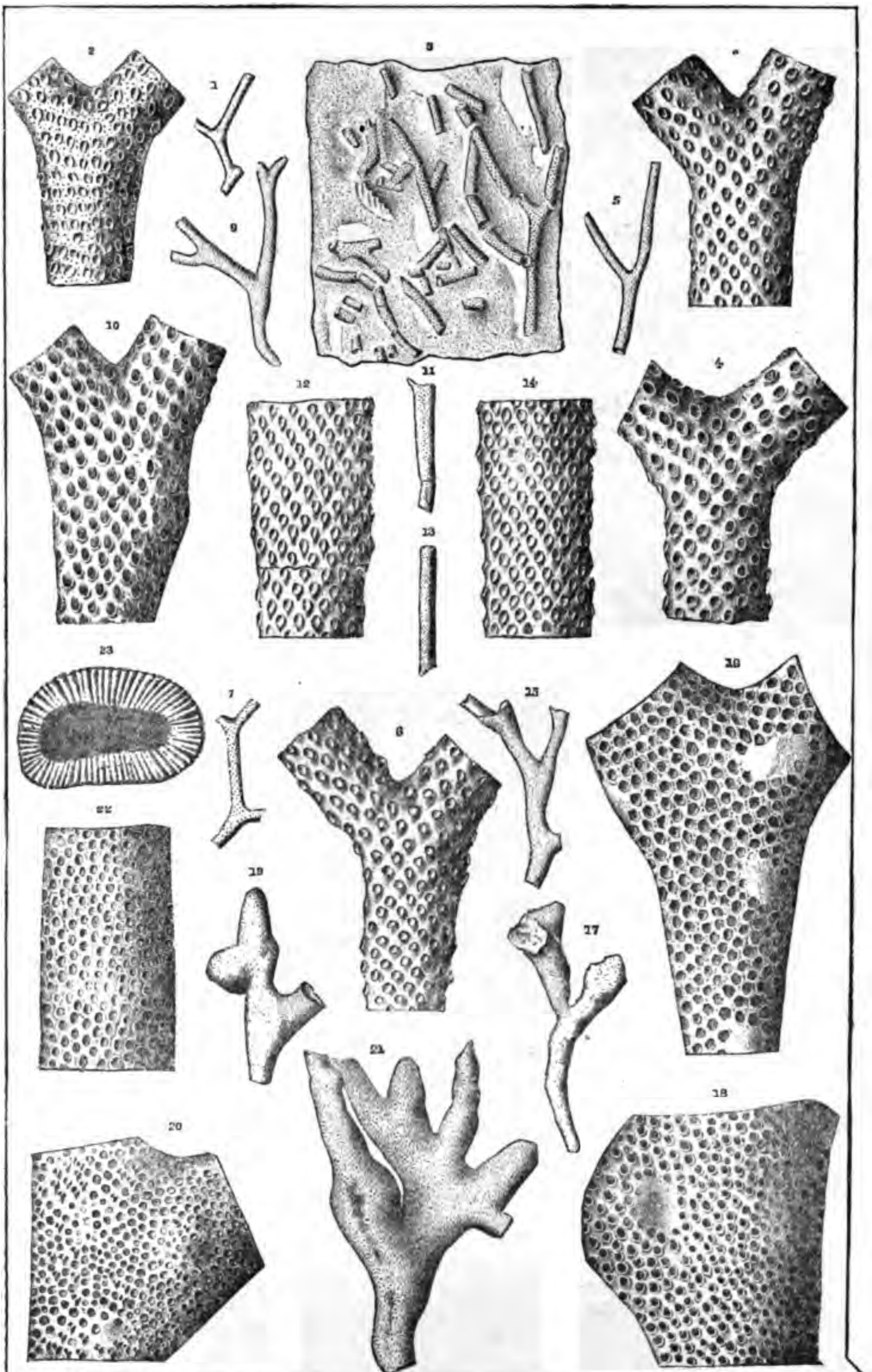

PLATE 10.

TREMATOPORA ECHINATA, *Hall.*

Page 233.

Figs. 1, 2. A small branch, natural size, and an enlargement of the bifurcation, showing the character of the cells.

Fig. 3. An enlargement from another individual where the cells are not so elongate as in the preceding one. This one and fig. 2 are enlarged eight diameters.

Fig. 4. An enlargement to twelve diameters from a specimen preserving, in great perfection, the spines at the cell-angles.

Fig. 5. A still further enlargement of the walls of a cell.

TREMATOPORA GRANULIFERA, *Hall.*

Page 233.

Fig. 6. An enlargement of a bifurcating branch, to two diameters.

Fig. 7. A still further enlargement from the above specimen, to show the arrangement of cells and the granulations on the intercellular spaces.

TREMATOPORA MINUTA, *Hall.*

Page 234.

Fig. 8. An enlargement to about twelve diameters, of a small branch of this species, showing the arrangement of cells.

TREMATOPORA VARIOLATA, *Hall.*

Page 234.

Fig. 9. A branch of the species, natural size.

Fig. 10. An enlargement from a part of the same, showing the scattered pores.

TREMATOPORA SPICULATA, *Hall.*

Page 235.

Fig. 11. A specimen of the natural size, showing the mode of growth.

Fig. 12. An enlargement from the central portion of the specimen, showing the character of the surface and the minute spinules at the angles of the cells.

STICTOPORA SIMILIS, *Hall.*

Page 247.

Figs. 13, 14. A small bifurcating fragment with oval cellules, natural size and enlarged.

Figs. 15, 16. Similar views of another individual of greater width, showing more crowded cellules.

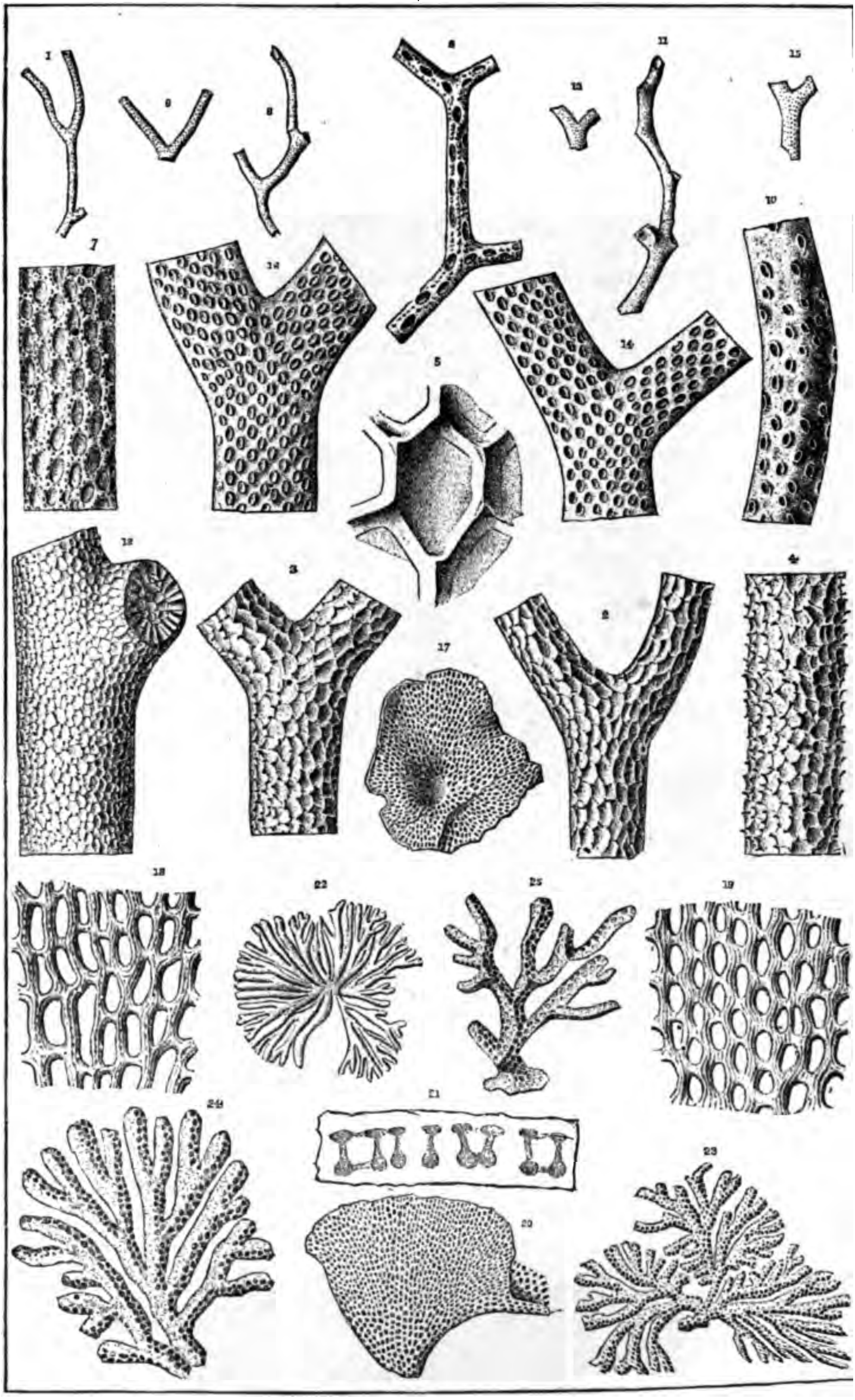
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PLATE 10—Continued.

FENESTELLA AMBIGUA, *Hall.*

Page 248.

Fig. 17. The inner surface of a frond, natural size.

Figs. 18, 19. Enlarged views of the opposite faces of the above specimen, showing a slight difference in the character of the striation of the two sides of the frond.

Fig. 20. The exterior surface of a flattened frond, showing a portion of the interior surface at the right hand side.

Fig. 21. An enlargement from the edge of the specimen fig. 20, showing a section. The rays of the inner and outer layers of the frond are connected by the vertical extensions, and the rays of the same layer connected by the transverse or horizontal dissepiments.

THAMNISCUS NIAGARENSIS, *Hall.*

Page 254.

Fig. 22. The non-poriferous face of a frond, natural size, showing the mode of growth and absence of transverse dissepiments.

Fig. 23. An enlargement of the poriferous face of a frond, to two diameters.

Fig. 24. A still farther enlargement of the right hand third of the frond fig. 23, to show the angular crest of the branches and the disposition of the pores upon its surface.

Fig. 25. An enlargement, to three diameters, of another fragment, showing the base of attachment, the angular crest of the branches and the extensions of the pores over the root-like base.

PLATE 11.

FENESTELLA PARVULIPORA, *Hall.*

Page 249.

Fig. 1. The non-poriferous surface of a fragment of a frond, natural size.

Fig. 2. An enlargement of a portion of the same to show the character of the surface and mode of reticulation.

Fig. 3. A similar fragment, having young specimens of Lichenalia and Ceramopora growing upon its surface (see plate 6, figs. 4 and 5, and plate 7, figs. 1 and 2).

Fig. 4. An enlargement from a portion of the opposite or celluliferous face of the frond fig. 3.

Fig. 5. A still farther enlargement of this surface, to show more distinctly the arrangement of the pores and the line of nodes on the median crest.

Fig. 6. An enlargement of the non-celluliferous face of the same frond, fig. 3, showing the absence of striation upon the surface.

Fig. 7. A portion of a very large frond, natural size, showing the general aspect of the species.

Fig. 8. An enlargement of the surface of the specimen fig. 7, showing the existence of very fine striæ.

Fig. 9. The interior of a frond, retaining the cup-shaped form. The surface here presented is non-celluliferous.

FENESTELLA ACMEA, *Hall.*

Page 250.

Fig. 10. The outer surface of a funnel-shape frond, presenting the celluliferous side.

Fig. 11. An enlargement of a part to show the arrangement of the branches, the form of the cells and the median ridge, with its flattened spreading crest, which is seen on some of the rays in the upper part of the figure, and on all below the bifurcation, while it is broken away in places, revealing the narrow slit thus left, which passes into the cavity of the ray below.

Fig. 12. Another fragment of the same species.

Fig. 13. An enlargement from a part of the preceding specimen, presenting wider fenestrules, and having the median crest entirely removed, showing only the narrow slit passing into the cavity of the branch. The connecting fenestrules are obscured over a part of this figure, as in fig. 11.

Fig. 14. An enlargement, to two diameters, of a part of a frond.

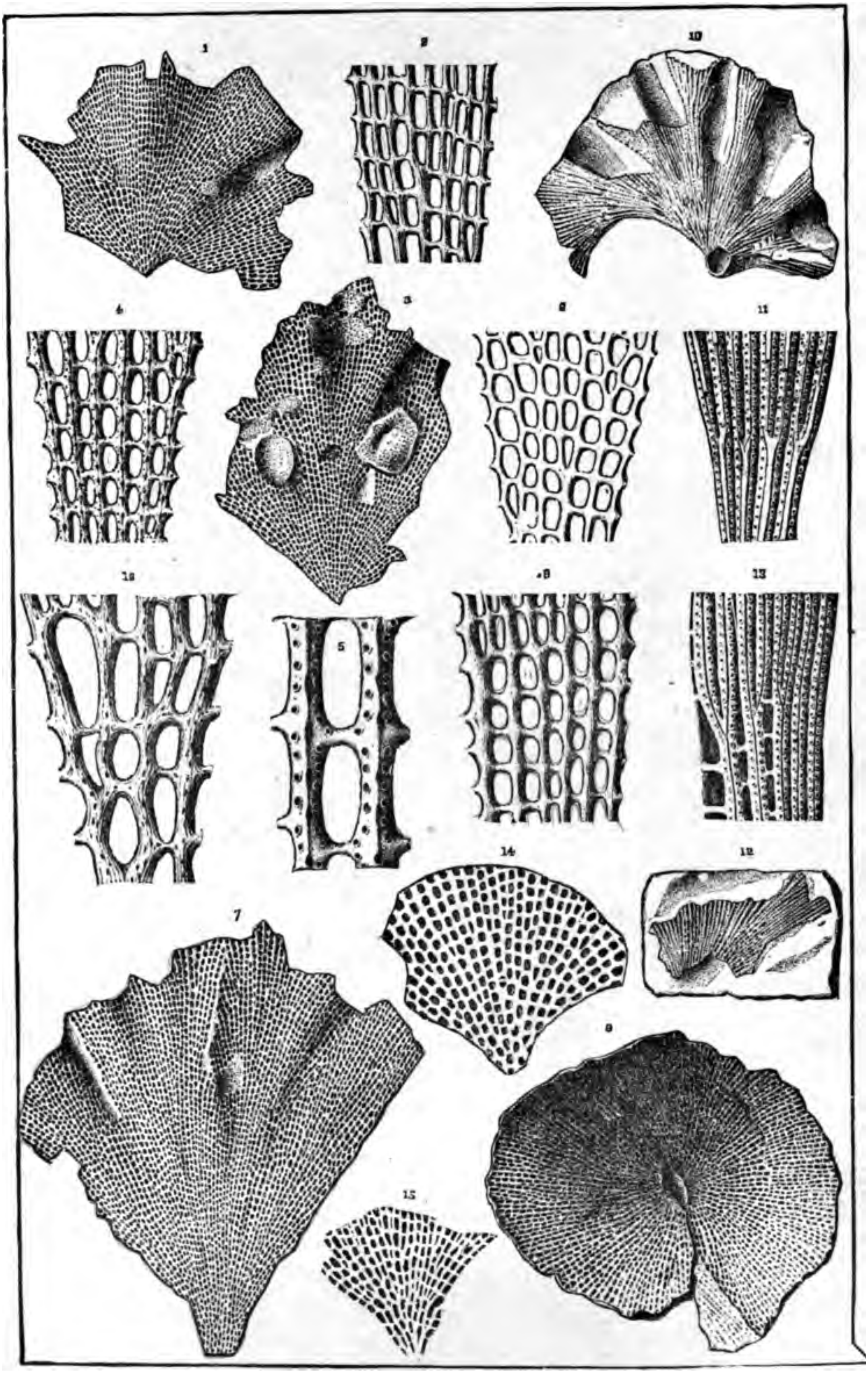

PLATE 12.

MACROSTYLOCRINUS STRIATUS, *Hall.*

Page 257.

Fig. 1. Lateral view of a small individual which shows the striations of the surface very perfectly.

Figs. 2, 3. The posterior and basal views of a larger specimen. The striations of the surface are not represented in the figure.

Fig. 4. An enlargement of the basal plate and one ray, showing the character of the surface striæ.

MACROSTYLOCRINUS FASCIATUS, *Hall.*

Page 258.

Figs. 5, 6. Lateral and basal views of a specimen, enlarged two diameters.

GLYPTASTER OCCIDENTALIS, *Hall.*

Page 262.

Figs. 7, 8. Basal and lateral views of a small, very perfectly preserved individual, enlarged to two diameters.

Fig. 9. Two of the rays with the interradial area still further enlarged to show the character of the surface-markings.

Fig. 10. The anterior side of a larger specimen, from which the basal plates have been removed, and the ridges not developed on the subradials.

Fig. 11. The posterior side of the same specimen as fig. 10.

SACCOCRINUS CHRISTYI, *Hall.*

Page 254.

Fig. 12. An enlargement to two diameters of the anal side of a small specimen, showing a small number of anal plates.

Fig. 13. Antero-lateral view of a larger specimen, on which the surface-striæ are very perfectly preserved.

Figs. 14, 15. The right and left sides of another individual.

Fig. 16. Anterior side of a larger specimen.

Fig. 17. The posterior side showing a larger number of plates than in fig 12.

Figs. 18, 19. The anterior and anal sides of a large specimen, which is slightly imperfect and somewhat obscured by attached bryozoans.

Fig. 20. An enlarged ray from specimen fig. 13, to show the character of surface-striæ.

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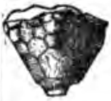

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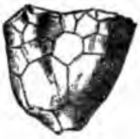

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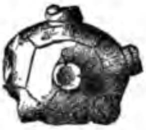

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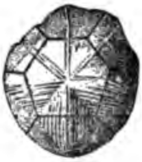

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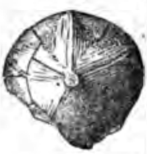

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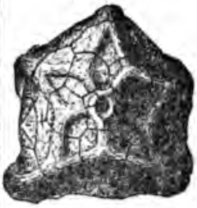

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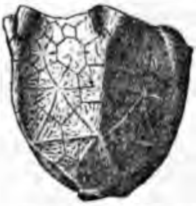

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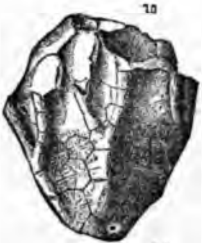

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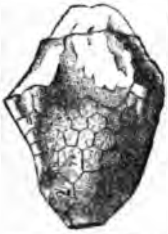

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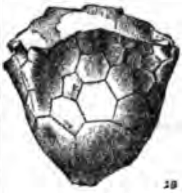

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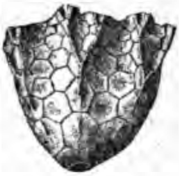

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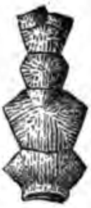

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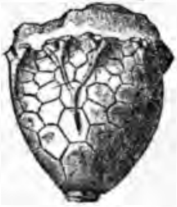

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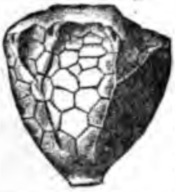

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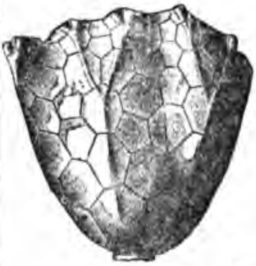

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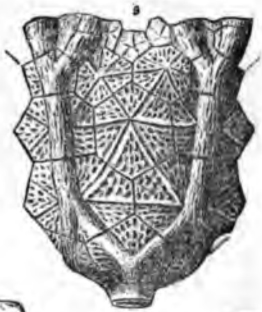

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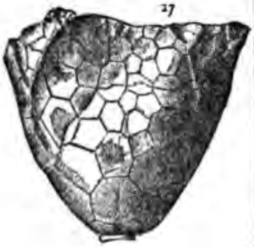

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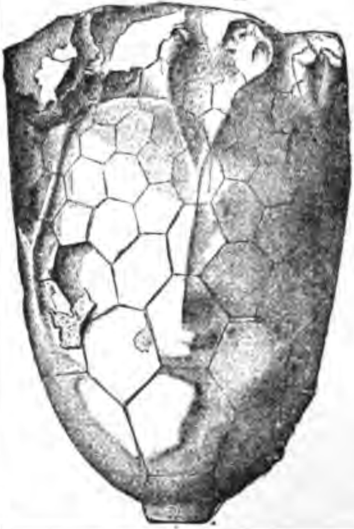

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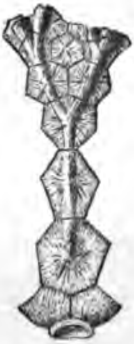

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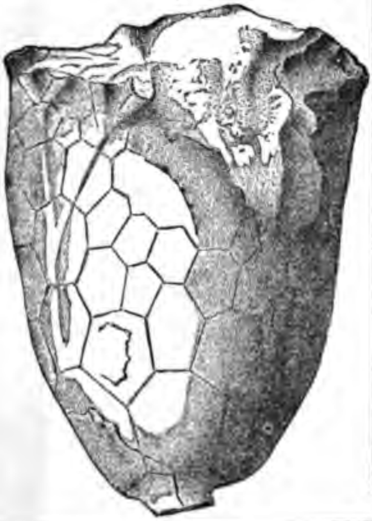

PLATE 13.

GLYPTASTER INORNATUS, *Hall.*

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Fig. 1. The anal area of a specimen which preserves the entire calyx.

Fig. 2. The anterior side of the same.

Fig. 3. A basal view of the same specimen.

Fig. 4. A basal view of the specimen fig. 6.

Fig. 5. A lateral view of the lower part of a calyx, on which the surface ornamentation is only partially developed.

Fig. 6. Lateral view of the specimen fig. 4, showing a grade of development of the surface ornamentation intermediate between specimens figs. 1 and 5.

GLYPTOCRINUS CARLEYI, *Hall.*

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Figs. 7, 8. Right and left lateral views of a nearly entire body, showing the general features of the species to the second bifurcation of the arms.

Fig. 9. A basal view of the preceding specimen.

Fig. 10. An enlargement of the central portion of fig. 8, to show more distinctly the surface characters.

MELOCRINUS OBCONICUS, *Hall.*

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Figs. 11, 12. Lateral and anterior views of a specimen, enlarged to two diameters, showing the form of plates and character of surface.

Fig. 13. The summit correspondingly enlarged, showing the plates of the dome.

Fig. 14. Basal view enlarged, as the preceding figures.

STEPHANOCRINUS GEMMIFORMIS, *Hall.*

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Figs. 15–17. Summit, basal and lateral views, enlarged to three diameters, showing the form and character of the body. The plates of the third range are shown upon the summits of the divisions of the calyx. Fig. 17 shows the characters of the surface markings.

Figs. 18–20. Lateral, basal and summit views of a larger specimen, somewhat different in form, with the third range of plates of larger size. Enlarged to three diameters.

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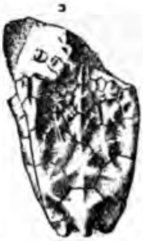

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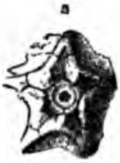

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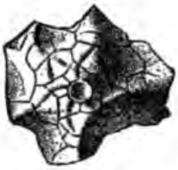

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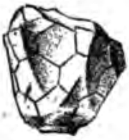

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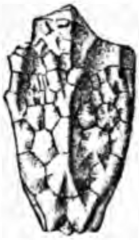

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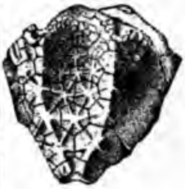

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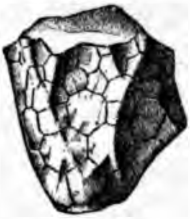

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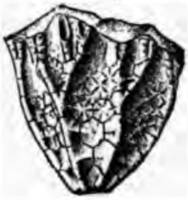

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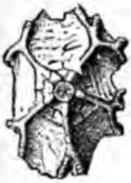

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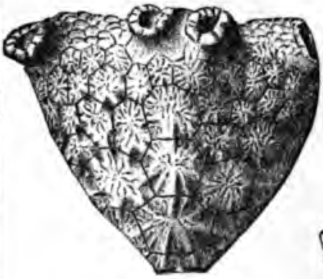

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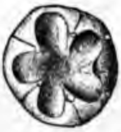

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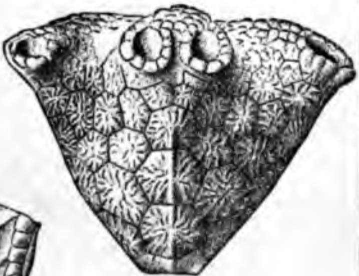

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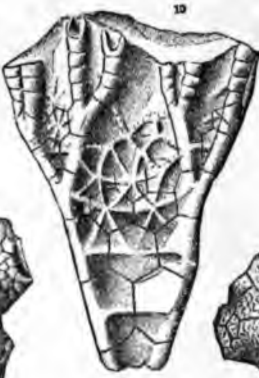

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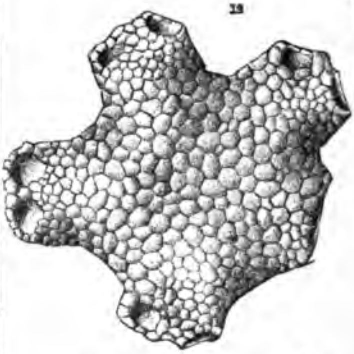

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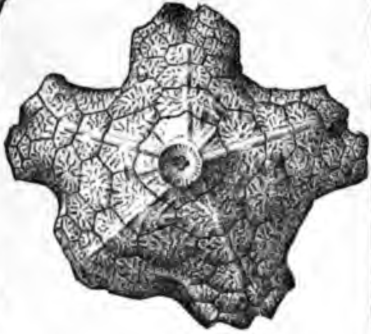

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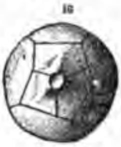

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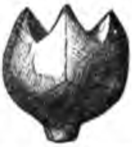

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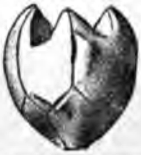

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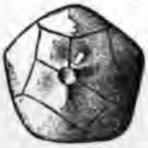

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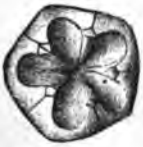

PLATE 14.

LECANOCRINUS PUSILLUS, *Hall.*

Page 267.

Figs. 1, 5. Anterior and posterior views of a calyx preserving the first and second anal plates; enlarged to two diameters.
Figs. 3, 4. Similar views of another specimen, natural size, where the two anal plates of the preceding specimen are represented by one only.
Fig. 2. The lower side of the last specimen, showing the size of the basal plates.
Fig. 6. An enlargement of a first radial plate, to show the surface-markings.

CYATHOCRINUS NUCLEUS, *Hall.*

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Figs. 7, 8. Lateral and anterior sides of the specimen, enlarged to four diameters, showing its form and character.
Fig. 9. Basal view of the same, enlarged to four diameters, showing the lobation of the body at the base of the arms.

CYATHOCRINUS POLYXO, *Hall.*

Page 264.

Figs. 10, 11. Lateral and basal views of a small specimen showing the basal plates with a small perforation in the middle.
Fig. 12. Anterior view of a larger specimen, showing the usual character of the species.
Figs. 13, 14. Posterior and basal views of a large individual, showing the very large second anal plates, and large opening through the basals. In this specimen the angular character of the plates, as observed in younger specimens, is greatly subdued.
Figs. 15, 16. Posterior and basal views of a specimen, showing features similar to the last.
Fig. 17. Posterior side of a specimen, showing a part of a third anal plate.

LYRIOCRINUS MELISSA, *Hall.*

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Fig. 18. The summit of a large individual preserving the plates of the dome, and also showing evidence of a subcentral proboscis.
Fig. 19. Basal view of a large imperfect specimen, showing flattened nodes on the subradial plates.
Figs. 20, 21. Basal and lateral views of a very symmetrical specimen, presenting the general form and features of the species to the arm-bases.
Fig. 22. Basal view of a specimen of ordinary size, showing a thickened, depressed, pentagonal ring around the column cicatrice, and incipient or developed nodes on the first radial plates. The surface of the plates is beautifully striated.

NIAGARA GROUP.

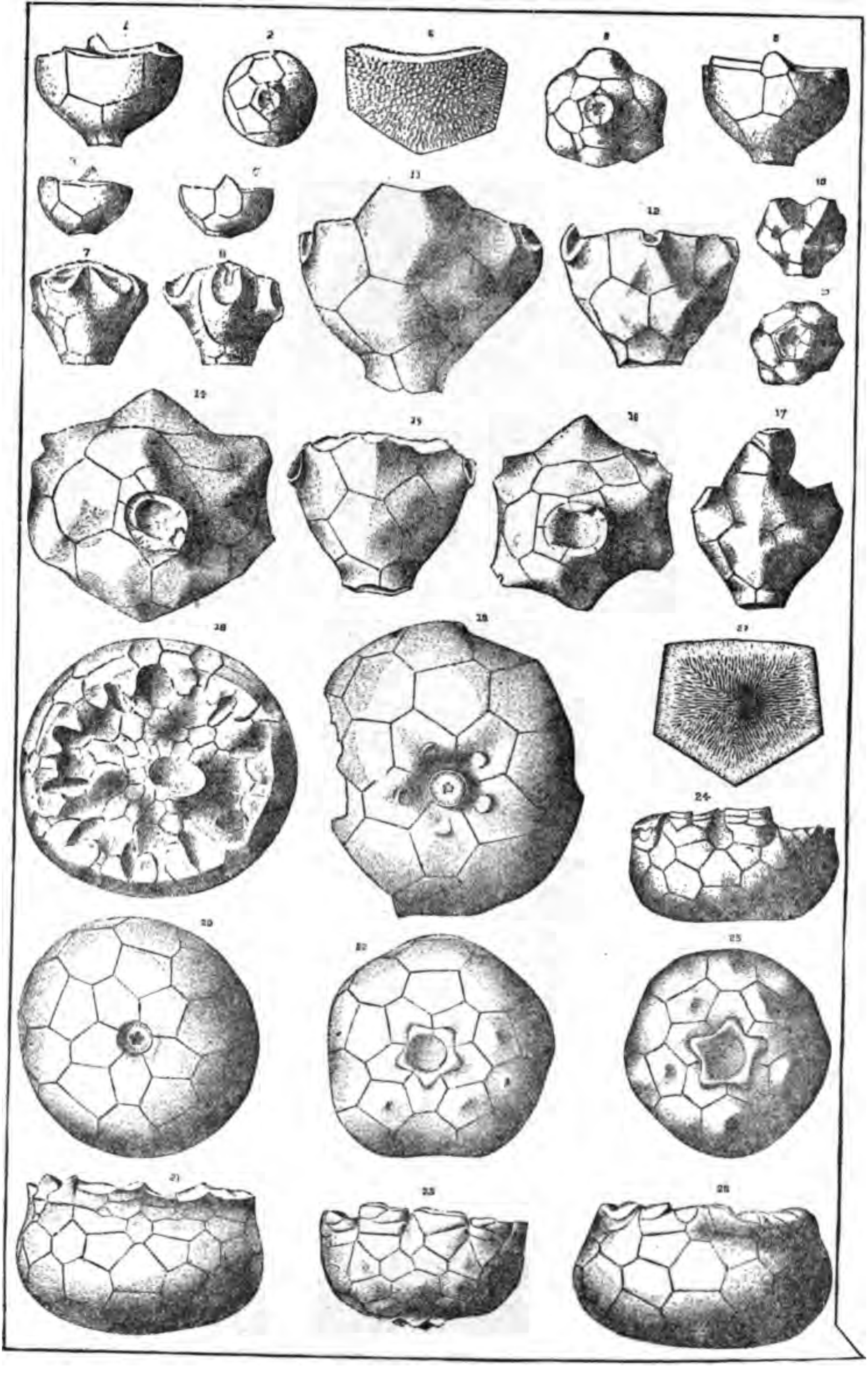

PLATE 14—Continued.

Fig. 23. Lateral view of a similar individual, enlarged to two diameters, showing a projecting pentalobate base with nodose radial and interradial plates.

Fig. 24. Lateral view of the specimen fig. 22, showing arm-bases, with arm-plates attached.

Fig. 25. Basal view, enlarged, of the specimen fig. 23, showing the nodes on the first radial plates.

Fig. 26. Lateral view of the specimen fig. 18.

Fig. 27. An enlargement of a first radial plate of specimen fig. 22, showing the character of the surface striæ.

PLATE 15.

EUCALYPTOCRINUS CONSTRICTUS, *Hall.*

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Fig. 1. Lateral view of the specimen described, showing the form of the calyx.

EUCALYPTOCRINUS CÆLATUS, *Hall.*

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Fig. 2. View of a specimen preserving the arms, calyx and a portion of the column.

SACCOCRINUS CHRISTYI, *Hall.*

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Fig. 3. The plates of a radial series showing the nodes, ornamentation, and bifurcation of the arms.

Fig. 4. The summit of a specimen, partially encrusted with a *Lichenalia.*

GLYPTOCRINUS CARLEYI, *Hall.*

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Fig. 5. The summit, showing the fine granulated character of the ornamentation of this portion, and the number and arrangement of the arm-bases.

LAMPTEROCRINUS PARVUS, *Hall.*

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Fig. 6. Lateral view, showing the arrangement of the plates and the position of the proboscis.

LECANOCRINUS PUSILLUS, *Hall.*

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Fig. 7. A specimen preserving the arms and a portion of the column.

CODASTER PULCHELLUS, *Miller & Dyer.*

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Fig. 8. Summit of a specimen showing its usual characters, enlarged two diameters.

Fig. 9. Natural size of same.

Fig. 10. Lateral view of a large individual showing the structure of the calyx.

NIAGARA GROUP

PLATE 15.

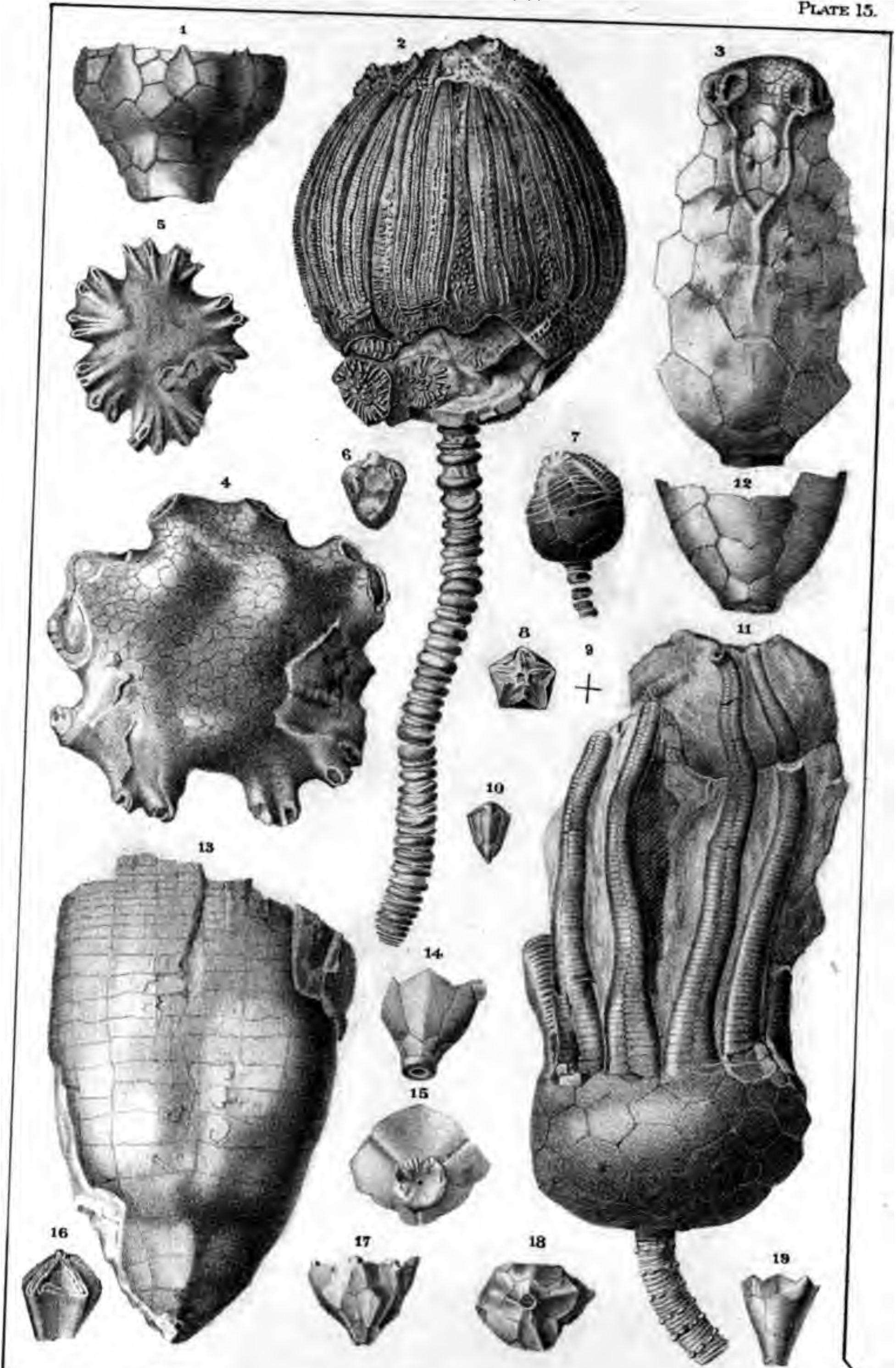

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PLATE 15—Continued.

LYRIOCRINUS MELISSA, *Hall.*

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Fig. 11. A specimen retaining the arms and a portion of the column.

ICHTHYOCRINUS SUBANGULARIS, *Hall.*

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Fig. 12. Basal portion of a specimen showing the emargination and interlocking of the plates.

Fig. 13. Lateral view of an individual showing the first, second, third and fourth radial series of plates.

POTERIOCRINUS? CALYX, *Hall.*

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Fig. 14. View of the specimen described.

PLATYCRINUS SILURICUS, *Hall.*

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Fig. 15. The base of a calyx showing the large strong plates.

CODASTER PENTALOBUS, *Hall.*

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Fig. 16. Lateral view of the imperfect specimen described.

AMPHERISTOCRINUS TYPUS, *Hall.*

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Fig. 17. Lateral view showing the arrangement of the plates and arm bases.

Fig. 18. Basal view showing the angular form of the calyx, and the extension on the anal side.

DENDROCRINUS ANCILLA, *Hall.*

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Fig. 19. Lateral view of the specimen showing the arrangement of the plates.

PLATE 16.

EUCALYPTOCRINUS CÆLATUS, *Hall.*

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Fig. 1. A young individual enlarged to three diameters. The divisions of the arm-plates are incorrectly represented.

Fig. 2. A larger individual preserving the arms in place, but the divisions of the arm-plates are not fully shown in the figure.

Fig. 3. Lateral view of the calyx of a full-grown individual, of the prevailing form.

Fig. 4. Basal view of the same.

Fig. 5. A lateral view of a specimen showing the calyx and the solid interbrachial plates of one side.

Fig. 6. The opposite side of the same specimen, which is broken so as to reveal the visceral cavity, above which are the interior dome plates, covering the canal leading to the exterior. These anchylosed plates are embraced and supported by the inner edges of the interbrachial plates, as shown in the figure.

Fig. 7. The summit of the same specimen, showing the interbrachial plates, and the accessory plates, surrounding the orifice at the summit. The upper side of the figure, where the exterior is broken away, shows distinctly the bases of two interbrachial plates, and the projecting angles of the interior dome plates.

Fig. 8. The upper margin and interior of a calyx, showing the plates and cicatrices for the attachment of the arms and interbrachial plates.

Figs. 9, 10. Interior and lateral views of the basal and subradial plates of the species, showing the division of the basal plates, as seen on the inner side, and their great development in the interior of the calyx.

These are rarely distinguishable within the column cavity, and probably never on the exterior surface.

ICHTHYOCRINUS SUBANGULARIS, *Hall.*

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Figs. 11, 12. Lateral and basal views of a fragment, showing subradial and radial plates with a decided pentangular outline.

Fig. 13. Lateral view of a larger fragment, showing the rays to near the third division on two of the series, and a less decided subangularity of the body in the lower parts than the preceding specimen.

NIAGARA GROUP.

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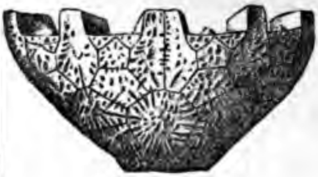

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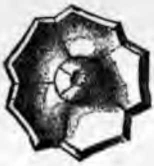

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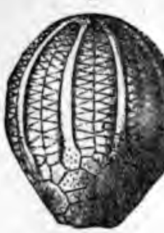

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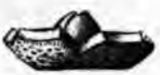

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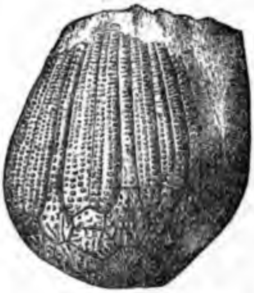

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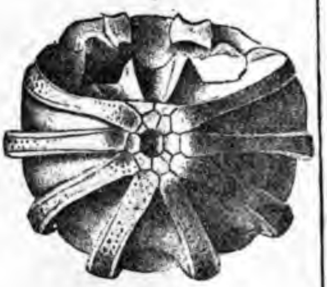

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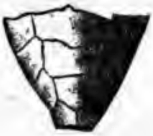

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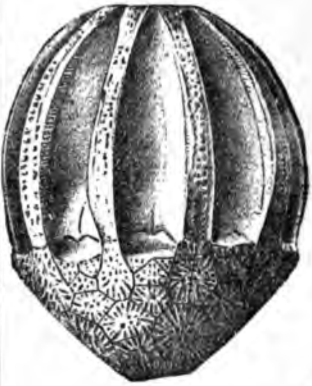

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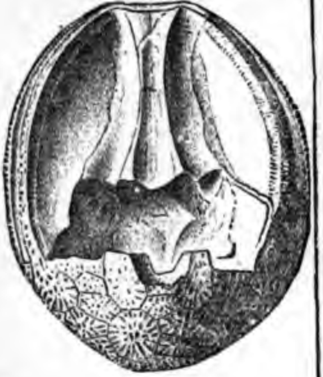

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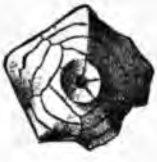

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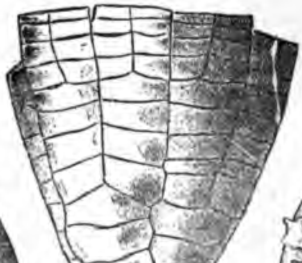

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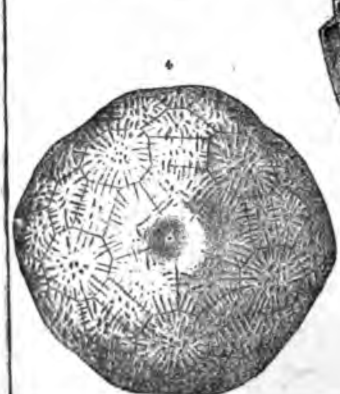

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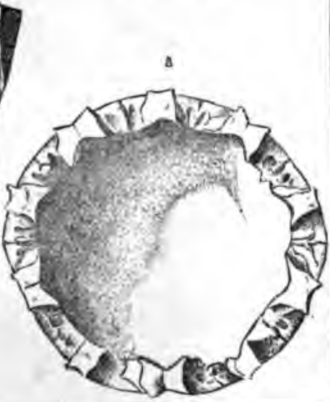

PLATE 17.

EUCALYPTOCRINUS CRASSUS, *Hall.*

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Fig. 1. A young individual, natural size, showing the immature character of the arms.

Fig. 2. An enlargement, to three diameters, of another young specimen, showing the immature character of the arms. The plates of the body have the same features as in the more advanced stages of growth.

Fig. 3. A young specimen retaining the interbrachial plates, but without the arms, the impression of the tentaculæ being retained on the sides of these plates.

Fig. 4. A young specimen similar to the preceding, referred to this species, but of a more globular form and spreading calyx.

Fig. 5. A young individual retaining the arms in place, and having the column and roots entire.

This is the only specimen yet found, retaining all the parts complete, among many hundreds of imperfect individuals which have been collected at the locality.

Fig. 6. Lateral view of an extremely elongated calyx.

Fig. 7. Lateral view of a more spreading form, retaining parts of the arms in place.

Fig. 8. Lateral view of a more elliptical specimen, preserving the interbrachial plates without the arms.

Fig. 9. A fragment of a column from the upper and middle portions, belonging apparently to a medium-sized specimen of this species. Two colonies of Favosites have commenced their growth upon it.

Fig. 10. The lower part of an interbrachial plate, showing the impression of the tentaculæ and the arm-plates.

Fig. 11. An enlargement of a part of an arm, showing the tentaculæ and edges of the arm-plates.

EUCALYPTOCRINUS OVALIS, *Troost.*

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Fig. 12. Lateral view of a very perfect specimen, possessing the form and general characters of the species ascribed to it by Dr. Troost. The arms of this species appear more mature than the young referred to *E. crassus*, except in the specimen fig. 5.

Fig. 13. An enlargement of the summit of the specimen fig. 12, showing the arrangement of the plates at the summit with the oral plates.

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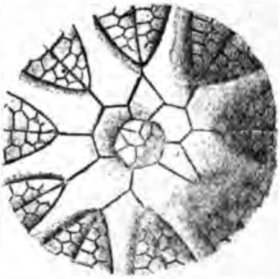

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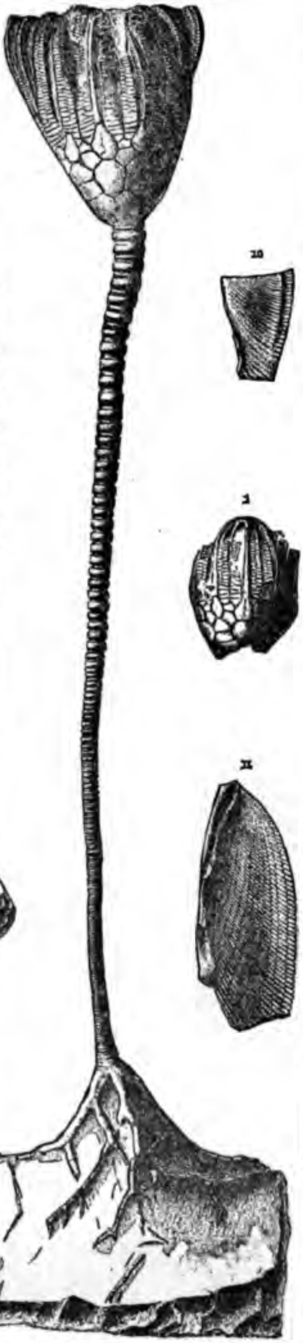

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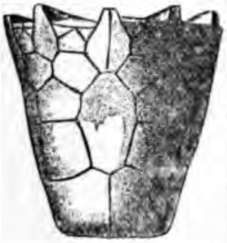

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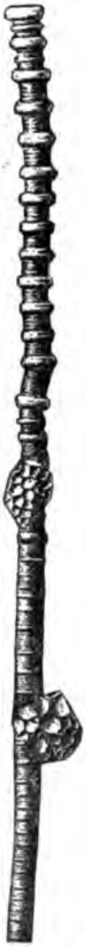

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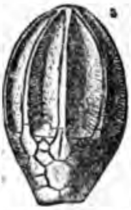

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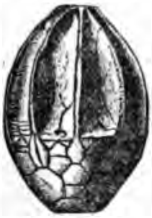

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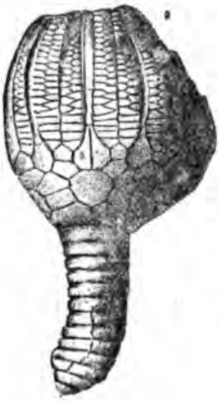

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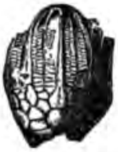

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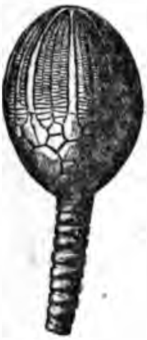

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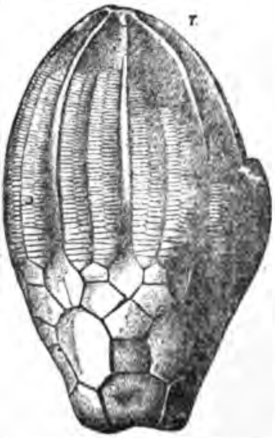

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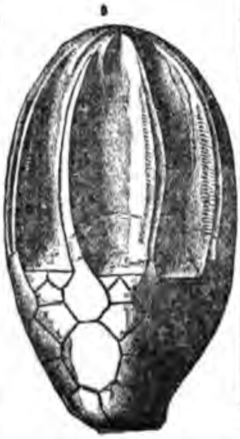

PLATE 18.

EUCALYPTOCRINUS CRASSUS, *Hall.*

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Fig. 1. Lateral view of a large calyx, which is constricted below the middle.

Fig. 2. Lateral view of a specimen without the constriction, with regularly sloping sides. The specimen preserves some of the lower plates of the arms.

Fig. 3. Basal view of the specimen fig. 1, showing the arrangement of plates and the deep cavity for the reception of the column, with the basal plates in the bottom.

Fig. 4. Lateral view of a large specimen, preserving the interbrachial plates, the spaces between which are filled with limestone.

Fig. 5. The summit of the specimen fig. 4, showing lanceolate depressions in the upper end of the interbrachials apparently for the insertion of accessory plates.

Fig. 6. Lateral view of a smaller specimen, which is more pointed at the upper end, but otherwise retaining the character of this species.

Fig. 7. The summit of the preceding specimen, showing but two intercalated plates around the aperture.

Fig. 8. An enlargement from the summit of another individual, showing four intercalated plates.

Fig. 9. An enlargement of the bases of a pair of arms, and of the adjacent plates from fig. 7, plate 17, to show their arrangement.

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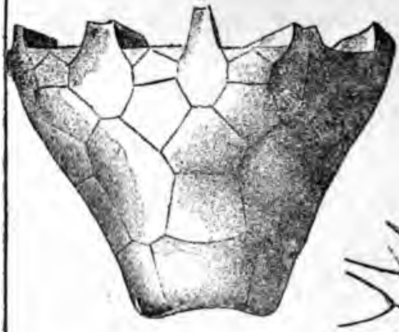

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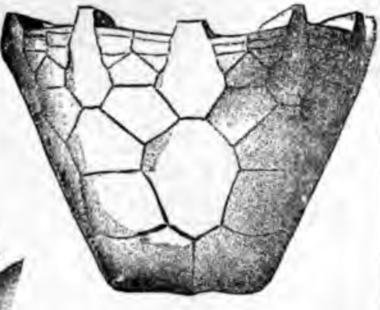

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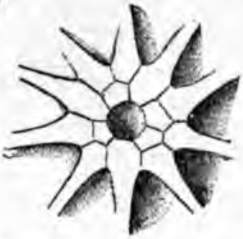

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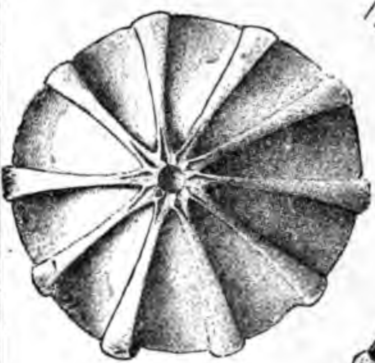

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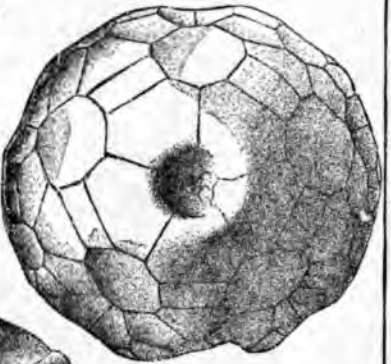

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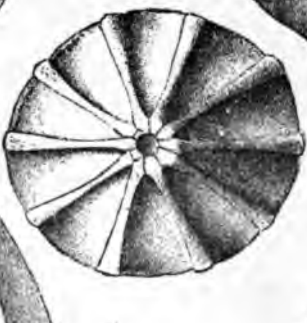

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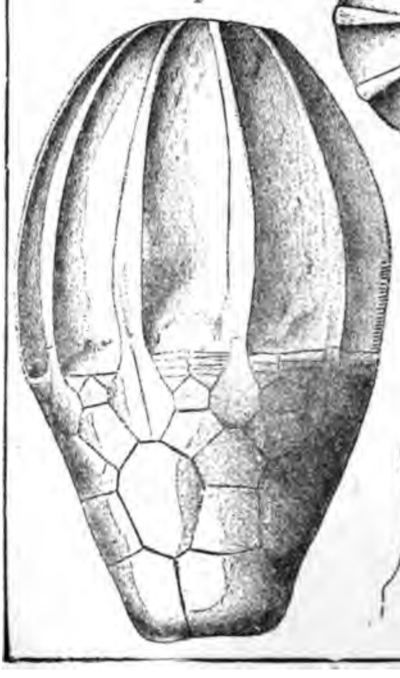

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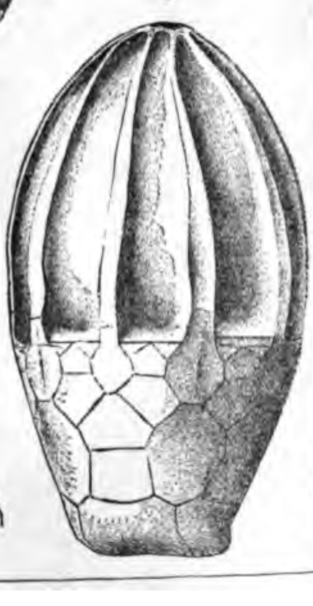

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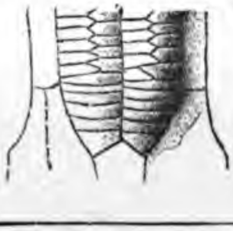

PLATE 19.

EUCALYPTOCRINUS CÆLATUS, *Hall.*

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Fig. 1. The interior of the dome of a large imperfect specimen, showing the supraradial plates of adjacent rays, with the double interradial plate between them in the lower central part of the figure; also the arm-openings (the rhomboidal depressions) and the plates forming the lower part or sides of the dome. Above this is the dome covering the aperture which, in the lower part, is composed of four anchylosed plates, as farther shown in figure 3. These are surmounted by a fluted hollow column, which reaches to the summit of the interbrachial plates. In this specimen it is broken off above. On the outer parts of the figure on either side may be seen the interbrachial plates, with the sutures dividing them from the inner parts.

Fig. 3. The lower concave surface of the anchylosed plates, which form the base of the dome over the visceral cavity of *Eucalyptocrinus cælatus.*

EUCALYPTOCRINUS CRASSUS, *Hall.*

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Fig. 2. The upper rim of a flattened calyx of this species, showing the cicatrices for the attachment of the arms and interbrachial plates.

Figs. 4, 5. The outer and inner surfaces of a lower dome plate of this species, showing it to be of much greater length than the corresponding part of *Eucalyptocrinus cælatus.*

Roots of EUCALYPTOCRINUS.

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Figs. 6, 7. Upper and lateral views of a group of roots, which have grown upon the exterior of a calyx of *Eucalyptocrinus cælatus.*

Fig. 8. The upper side of a larger root with base of column, which has grown upon the surface of the calcareous mud of the sea bottom.

CALCEOCRINUS STIGMATUS, *Hall.*

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Fig. 9. Dorsal view of the body of a specimen enlarged to two diameters.

Fig. 10. Ventral side enlarged to two diameters, showing the scars for the attachment of the lateral and dorsal arms, and for the ventral plates.

Fig. 11. Lateral view of the same, enlarged.

NIAGARA GROUP.

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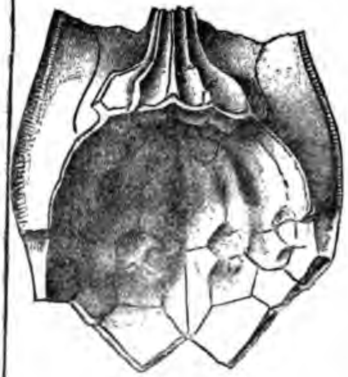

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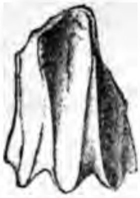

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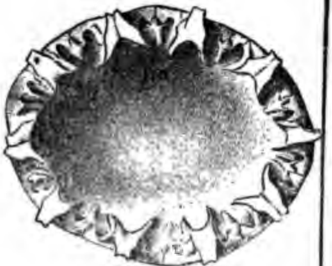

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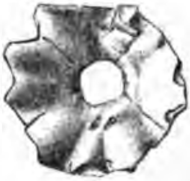

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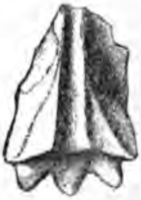

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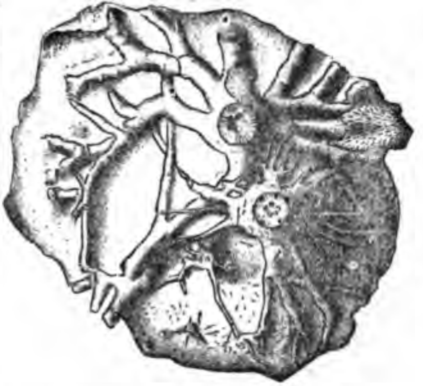

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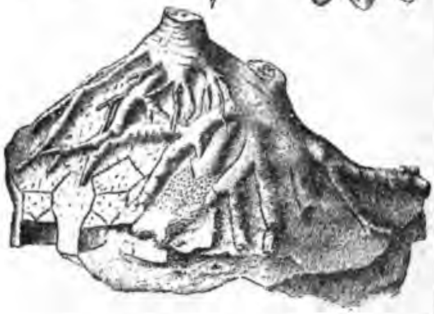

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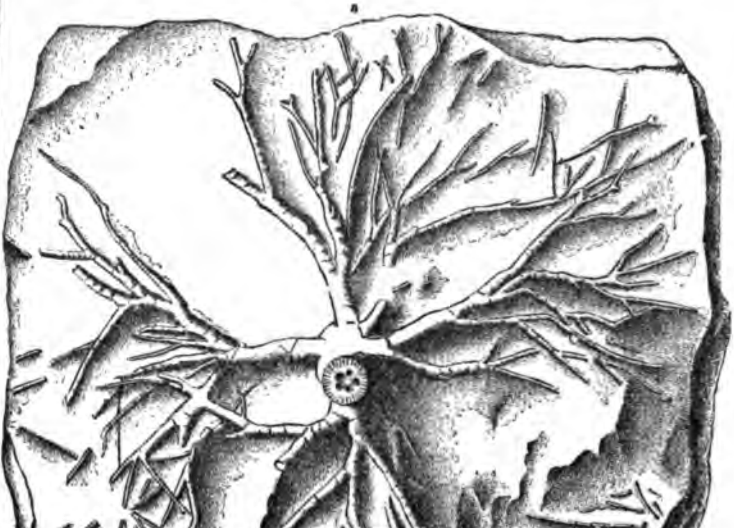

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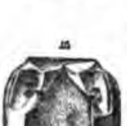

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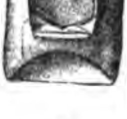

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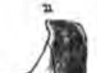

PLATE 20.

Roots of EUCALYPTOCRINUS.

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The specimen, which preserves the base of the column, shows the ramification of the rootlets through the calcareous shale, and was evidently imbedded during its growth upon the ocean bed.

Specimens sometimes occur with rootlets much more extended, and becoming uite filiform, but seldom traceable to their entire extent.

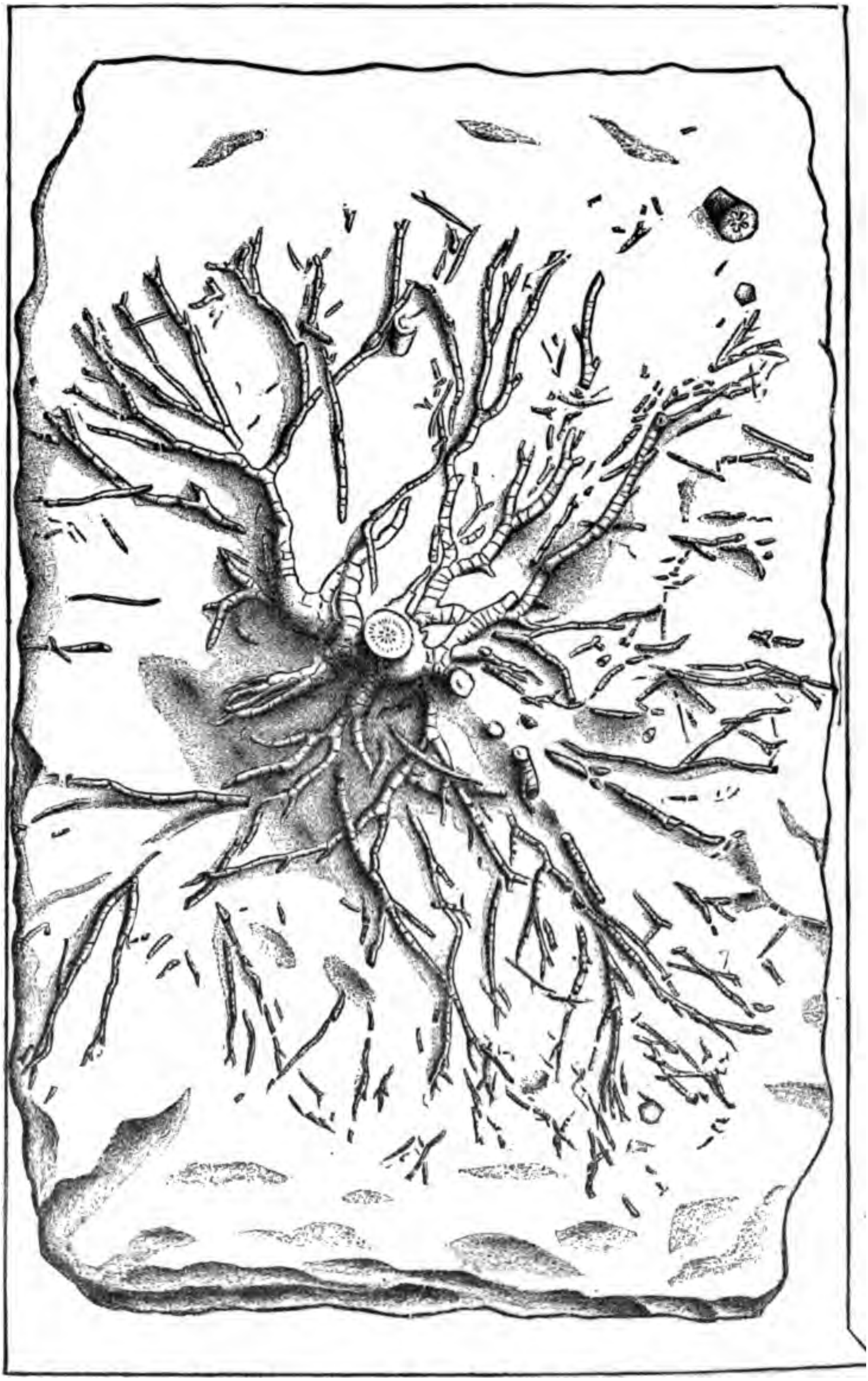

PLATE 21.

PHOLIDOPS OVALIS, *Hall.*

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Figs. 1, 2. The upper valve and profile view (greatly enlarged) of a specimen retaining both valves.

CRANIA SILURIANA, *Hall.*

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Fig. 3. A specimen which retains both valves, attached to the surface of a Spirifera.

Fig. 4. The upper valve of a specimen attached to the surface of *Platyostoma Niagarense*. Owing to the contour of the surface on which it has grown, the shell has become elongated and constricted on one side.

Fig. 5. A lateral view of the same, showing the elevation.

Fig. 6. The calyx of *Eucalyptocrinus crassus* with four ventral valves of the species attached.

Fig. 7. A specimen of *Rhynchonella Stricklandi* with a ventral valve of the species attached.

CRANIA SETIFERA, *Hall.*

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Fig. 8. A specimen which is imperfect around the margin, but shows the general features of the species.

Fig. 9. A lateral view of the same, restored on the edge, showing the elevation of the valve and the position of the apex.

Fig. 10. An enlargement of the surface to show the setiform spines.

ORTHIS ELEGANTULA, *Dalman.*

Page 285.

Figs. 11, 12. Ventral and dorsal views of a small specimen.

Fig. 13. Ventral view of a large individual.

Fig. 14. Lateral view of a similar specimen.

Fig. 15. Interior of a large ventral valve, showing the cardinal area, teeth and wide foramen.

Fig. 16. An enlargement to two diameters of the interior of a dorsal valve showing the muscular imprints, cardinal and crural processes, and external cardinal area.

Fig. 17. Cardinal view of the specimen fig. 14.

NIAGARA GROUP.

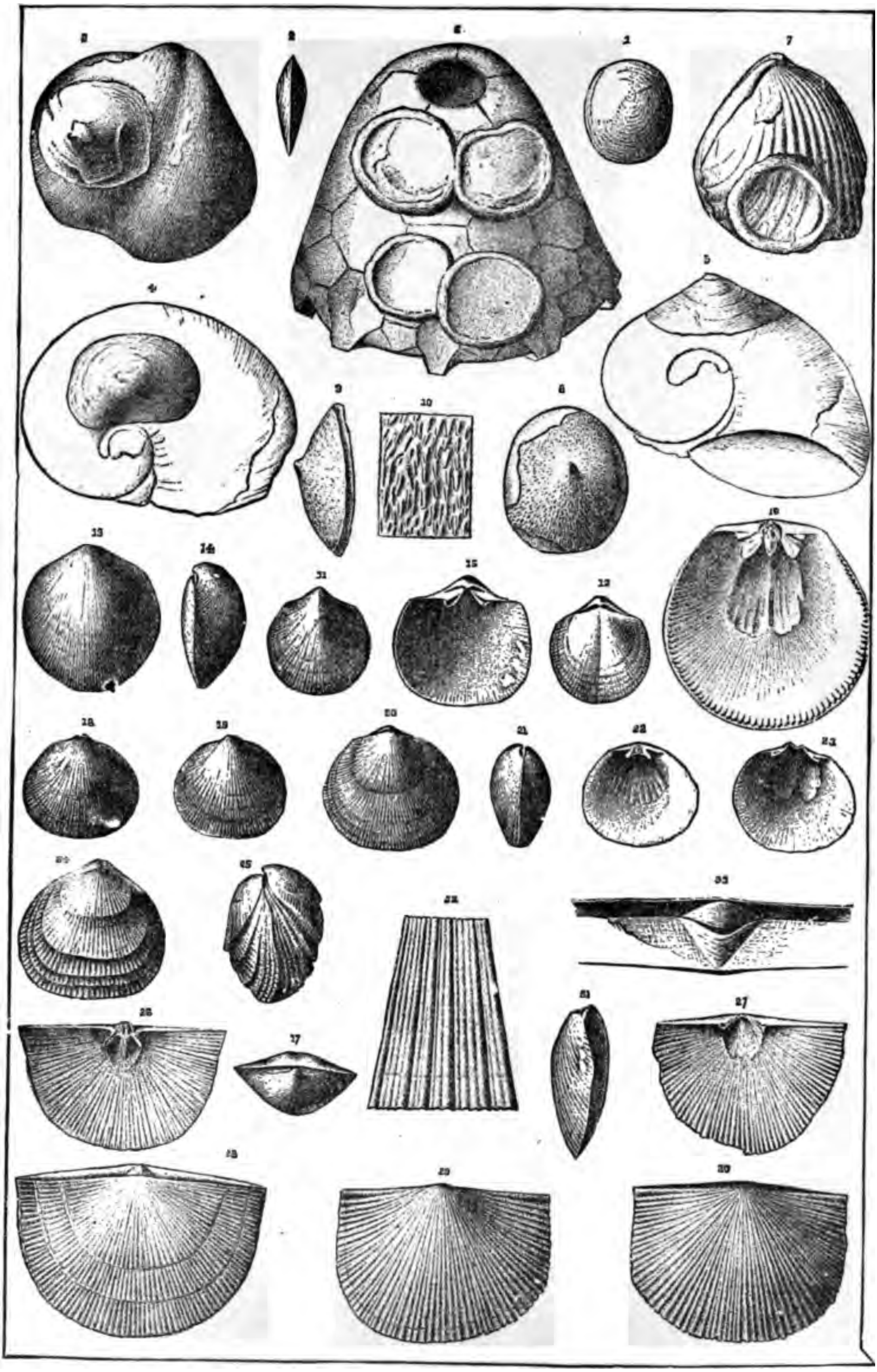

PLATE 21—Continued.

ORTHIS HYBRIDA, *Sowerby*.

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Fig. 18. Dorsal view of a specimen of the usual form and size.
Fig. 19. Ventral view of the same.
Fig. 20. Dorsal view of an unusually large specimen.
Fig. 21. Lateral view of the specimen figures 18 and 19, showing the relative convexity of the valves.
Fig. 22. The interior of a dorsal valve, showing the muscular impression, cardinal process, etc.
Fig. 23. The interior of a ventral valve, showing muscular imprints, teeth, etc. The shell is slightly distorted and imperfect on the cardinal margin.
Figs. 24, 25. Dorsal and lateral views of a small rotund specimen, showing strong varices of growth; enlarged to two diameters.

STREPTORHYNCHUS SUBPLANA, *Conrad*.

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Fig. 26. The interior of a dorsal valve, showing the cardinal process, etc.
Fig. 27. An imperfect ventral valve, showing muscular imprints, teeth and cardinal area.
Fig. 28. Dorsal view of a symmetrical specimen of the larger size.
Figs. 29, 30. Ventral and dorsal views of a specimen of the usual size of the species as it occurs at Waldron.
Fig. 31. Ventral view of the same, showing the convexity of the valves.
Fig. 32. An enlargement of the surface, showing the fine concentric striæ.
Fig. 33. An enlargement of the central part of the cardinal area of the united valves, showing the closed deltidium, the striæ, etc.

PLATE 22.

STROPHONELLA SEMIFASCIATA, *Hall.*

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Fig. 1. An imperfect dorsal valve.

Fig. 2. A more nearly entire specimen of the same valve, which presents the usual fasciculate characters of surface striæ.

Fig. 3. Cardinal view of a specimen, retaining both valves in place and showing strong deltidial coverings.

STROPHOMENA RHOMBOIDALIS, *Wilckens.*

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Fig. 4. The interior of a ventral valve, showing the muscular imprint.

Fig. 5. The dorsal view of a specimen, having both valves in connection.

Fig. 6. The ventral valve of the same.

Fig. 7. A lateral view of another specimen, with a ventral valve of *Crania Siluriana* attached.

Fig. 8. The upper part of a ventral valve, of a large specimen which preserves both valves, the cardinal line being shown near the lateral angles.

Fig. 9. The interior of a dorsal valve, showing muscular imprints, cardinal process, etc.

Fig. 10. An enlargement of the middle portion of the cardinal area of a specimen, with both valves in place, showing the back of the cardinal process of the dorsal valve filling the deltidial opening of the ventral valve. The central groove marks the division of the cardinal process.

CHONETES NOVA-SCOTICA, *Hall.*

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Fig. 11. A ventral valve showing the spines and the larger median striæ; enlarged to two diameters.

Figs. 12, 13. Two other ventral valves, natural size, showing the cardinal spines. The central part of these three figures is incorrectly represented as angular, instead of simply by a stronger median ray.

Fig. 14. An enlargement from the middle of a specimen to show the stronger central ray and fine concentric striæ.

CHONETES UNDULATA, *Hall.*

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Fig. 15. An enlargement to four diameters of an individual possessing the usual characters.

NIAGARA GROUP.

PLATE 22.

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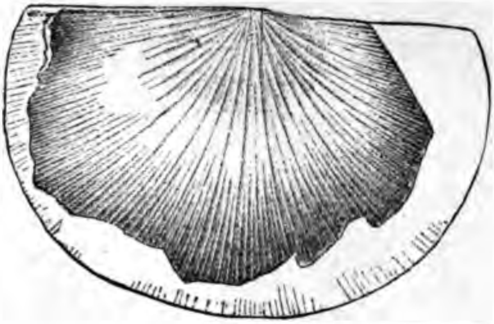

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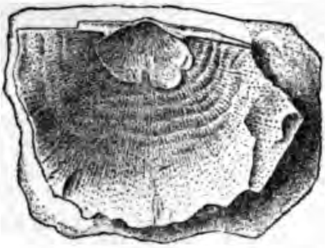

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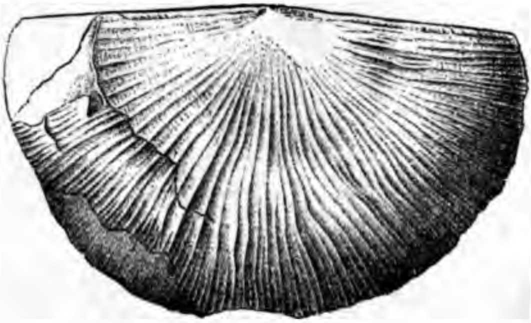

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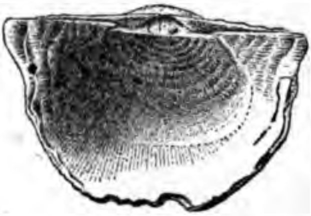

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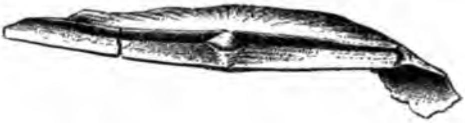

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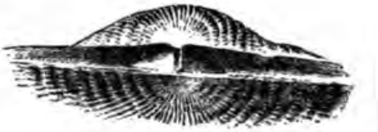

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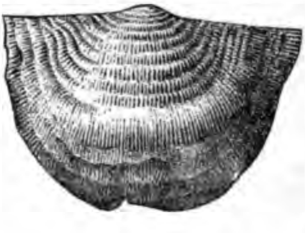

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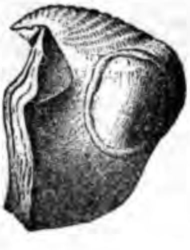

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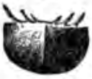

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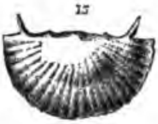

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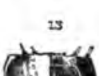

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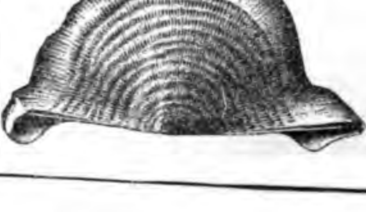

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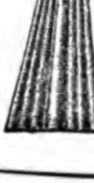

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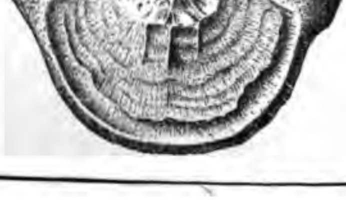

PLATE 23.

STROPHODONTA STRIATA, *Hall.*

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Fig. 1. A ventral valve showing the general form and the surface characters.
Fig. 2. The dorsal side of the same.
Fig. 3. A profile view, showing the relative convexity and the bending of the valves at the cardinal angles.
Fig. 4. The interior of a dorsal valve, showing the cardinal process, and crenulate margins.
Fig. 5. The interior of a ventral valve, showing the muscular imprint, the cardinal area and the crenulations on the hinge.
Fig. 6. An enlargement of the cardinal process of the dorsal valve, showing the grooving of the posterior face.

STROPHONELLA SEMIFASCIATA, *Hall.*

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Fig. 7. The ventral side of a large, nearly entire specimen.
Fig. 8. The interior of an imperfect dorsal valve, referred with doubt to this species, showing a minute cardinal process and crenulated hinge line.

STROPHODONTA PROFUNDA, *Hall.*

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Fig. 9. The interior of a ventral valve, showing the muscular imprint and cardinal area, with the hinge crenulations extending less than half its length.
Fig. 10. The exterior of an imperfect valve partially restored, showing the character of the striæ.

STREPTORHYNCHUS TENUIS, *Hall.*

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Fig. 11. An imperfect ventral valve, showing the rounded hinge extremity and the character of the surface striæ.
Fig. 12. A dorsal valve showing the form of the shell.
Fig. 13. An enlargement of the surface, showing the alternations of the radiating striæ and the finer concentric crenulating lines.

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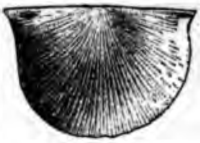

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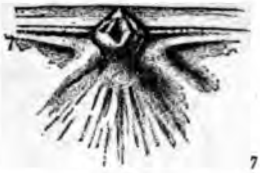

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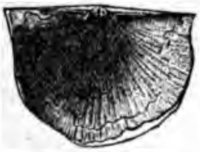

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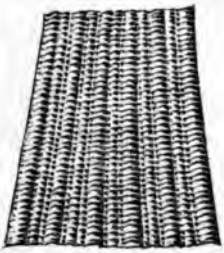

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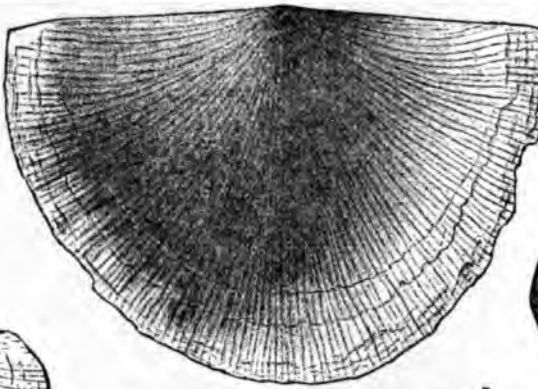

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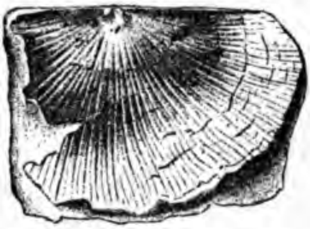

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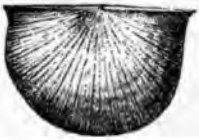

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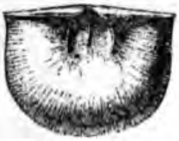

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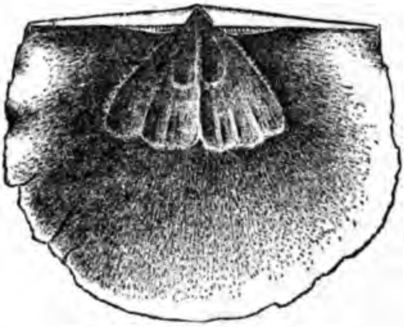

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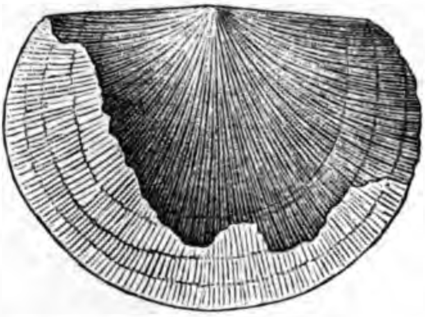

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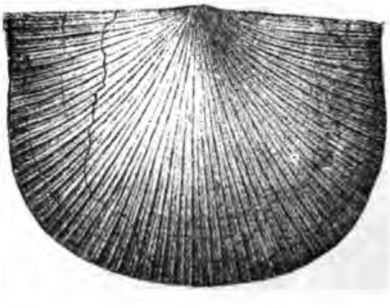

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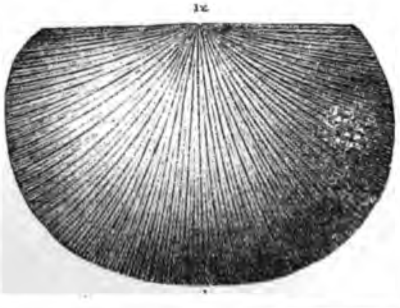

PLATE 24.

SPIRIFERA CRISPA (*Hisinger*) *var.* SIMPLEX, *Hall.*

Page 296.

Figs. 1-5. Dorsal, ventral, front, lateral and cardinal views of a specimen of this variety, enlarged to two diameters.

SPIRIFERA CRISPA, *Hisinger.*

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Fig. 6. Dorsal view of a specimen of the size and form usually obtained at this locality.

Fig. 7. Ventral view of a wider form.

Figs. 8-12. Dorsal, ventral, front, cardinal and lateral views of a larger specimen showing the character of the species, as it occurs at Waldron.

Fig. 19. The interior of a ventral valve, enlarged to two diameters.

SPIRIFERA EUDORA, *Hall.*

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Figs. 13-16. Dorsal, cardinal, front and lateral views of a specimen, presenting the features of the species, from the Waldron locality.

Fig. 17. A ventral valve, having the surface striæ strongly marked.

Fig. 18. Interior of a ventral valve, showing the cardinal area, the foramen and teeth.

SPIRIFERA RADIATA, *Sowerby.*

Page 296.

Fig. 20. Dorsal view of a specimen of medium size.

Fig. 21. Dorsal view of a nearly full-grown specimen.

Figs. 22-26. Dorsal, ventral, cardinal, lateral and front views of a large well-formed specimen, of the usual characters of the species as recognized at this locality.

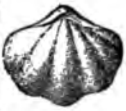
Fig. 27. Profile view of the specimen, fig. 21, for comparison with fig. 25.

Fig. 28. The interior of a ventral valve.

Fig. 29. The interior of the cardinal portion of a dorsal valve.

Fig. 30. An enlargement of the surface striæ. Figs. 17, 19, 22, 28, 29 and 30 are copied from Pal. N. Y., Vol. IV, Pt. II: *Revision of the Brachiopoda* (unpublished).

NIAGARA GROUP.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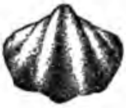
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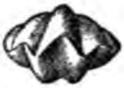
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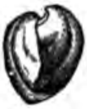
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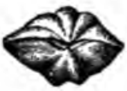
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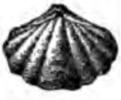
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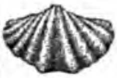
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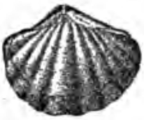
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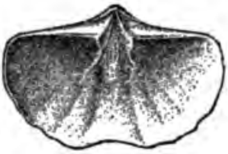
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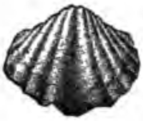
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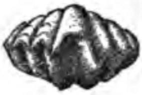
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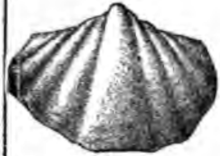
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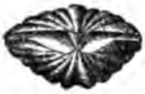
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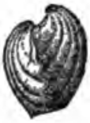
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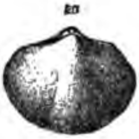
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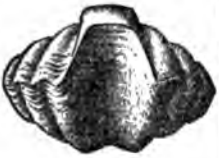
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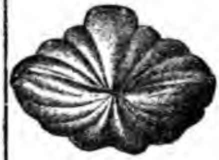
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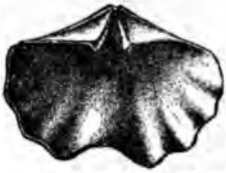
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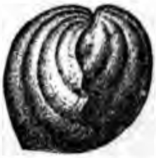
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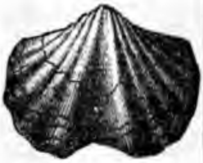
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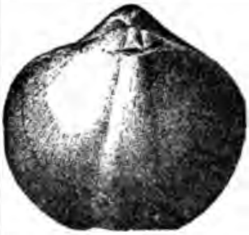
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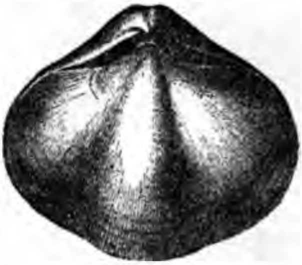
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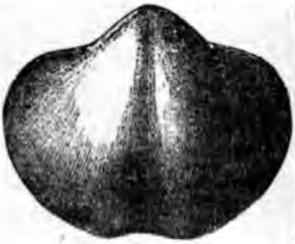
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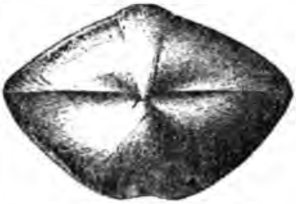
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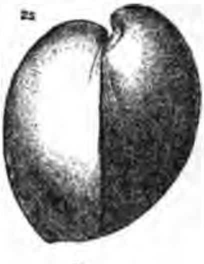
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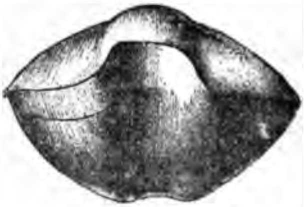
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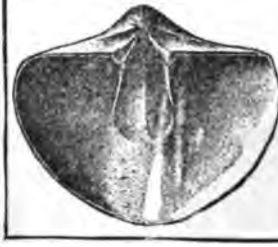
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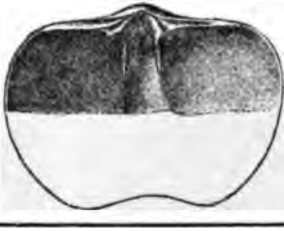
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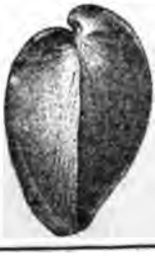
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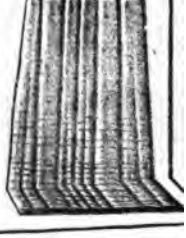
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PLATE 25.

MERISTINA NITIDA, *Hall.*

Page 300.

Fig. 1. Dorsal view of a small specimen of a rounded form.

Fig. 2. Ventral view of a rhomboidal specimen which is emarginate in front.

Fig. 3. Dorsal view of a large, broadly ovate form, which is emarginate in front and shows the foramen in the beak.

Fig. 4. Ventral view of a large rhomboid-ovate specimen, which is strongly emarginate in front.

Fig. 5. Lateral view of the specimen fig. 3, showing the convexity of the valves.

Fig. 6. Dorsal view of a narrow, elongate-ovate form, with a slight emargination in front.

Fig. 7. Dorsal view of a narrow, rhomboidal form, which is not emarginate.

Figs. 3, 5, 6 and 7 are copied from Pal., N. Y., Vol. IV, Pt. II: *Revision of the Brachiopoda*, (unpublished).

MERISTINA MARIA, *Hall.*

Page 299.

Fig. 8. Dorsal view of a young specimen which has not begun to develop the mesial elevation or sinus, and is proportionally broader than the mature, full-grown specimens.

Figs. 9, 10. Dorsal and front views of a large mature specimen.

Fig. 11. Front view of a specimen with the mesial fold much less strongly marked than fig. 10.

Fig. 12. Lateral view of the specimen fig. 9.

RETZIA EVAX, *Hall.*

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Figs. 13-17. Dorsal views of specimens varying in size and form, and exhibiting some of the phases which mark the species in its advanced stages of growth.

Fig. 18. Profile of the specimen fig. 14, showing the convexity of the valves.

Fig. 19. Ventral view of a specimen showing the mesial depression.

Fig. 20. Front view of the specimen figs. 14 and 18, showing the depth of the depression.

Fig. 21. Ventral view of a small, elongate form, showing finer plications—apparently a mature specimen.

NUCLEOSPIRA PISIFORMIS, *Hall.*

Page 301.

Figs. 22-25. Dorsal, ventral, lateral and cardinal views of a ventricose specimen, having much the appearance of *N. ventricosa* of the Lower Helderberg group.

NIAGARA GROUP

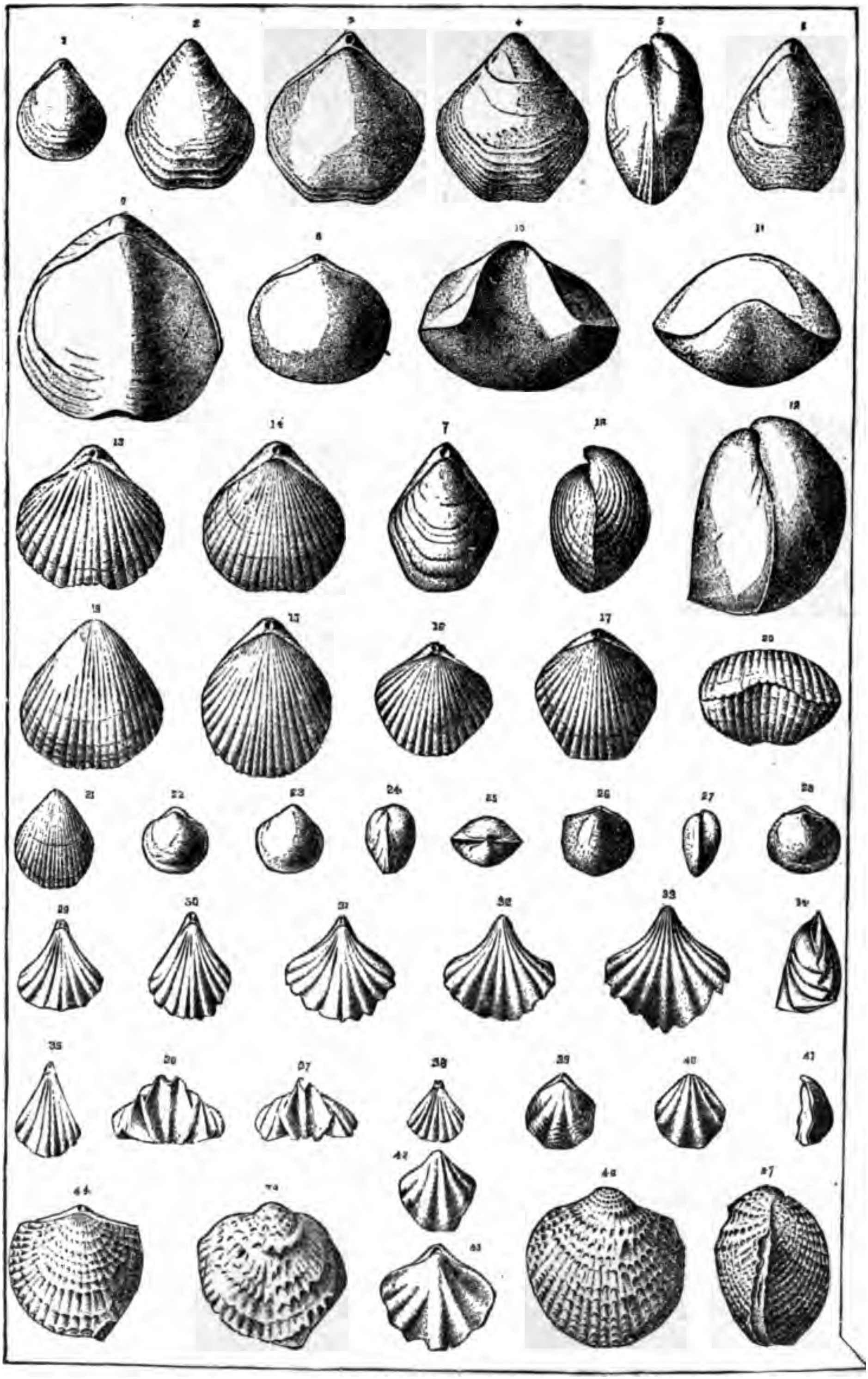

PLATE 25—Continued.

Figs. 26, 27. Dorsal and lateral views of a less ventricose specimen, with surface almost entirely covered by fine setæ.

Fig. 28. Dorsal view of a specimen with more prominent beak.

RHYNCOTRETA CUNEATA (*Dalman*) *var.* AMERICANA, *Hall.*

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Fig. 29. Dorsal valve of a small specimen of the usual form.

Fig. 30. Dorsal view of a more elongate form.

Figs. 31, 32. Dorsal and ventral views of a very broad specimen, having strong, slightly rounded plications.

Fig. 33. Ventral view of a large specimen, differing somewhat in form from the preceding.

Fig. 34. Lateral view of the specimens figs. 31 and 32.

Fig. 35. Dorsal valve of an extremely elongate form, with narrow plications.

Figs. 36, 37. Front views of the specimens fig. 33 and fig. 31, showing the elevation of the front.

Fig. 38. Dorsal view of a young shell before the development of the elevation of the front and depression of the sides has commenced.

CŒLOSPIRA DISPARILIS, *Hall.*

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Figs. 39–41. Dorsal, ventral and lateral views of a specimen, enlarged to two diameters, showing the usual character of the species.

Fig. 42. An enlargement of a ventral valve of a specimen of more elongate form and extended beak.

Fig. 43. An enlargement of the dorsal side of a broader specimen. The apex of the dorsal valve is represented a little too convex.

ATRYPA RECTICULARIS, *Linn.*

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Figs. 44, 45. Dorsal and ventral views of a specimen showing strong lamellæ fringing the concentric lines of growth.

Fig. 46. Ventral view of a larger and more ventricose specimen, with finer concentric markings.

Fig. 47. Lateral view of the same, showing the convexity of the valves.

PLATE 26.

RHYNCHONELLA NEGLECTA, *Hall.*

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Figs. 1, 2. Dorsal and front views of a specimen of the usual size.
Figs. 3-6. Dorsal, ventral, lateral and front views of a larger specimen.

RHYNCHONELLA ACINUS, *Hall.*

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Fig. 7. The dorsal side of a specimen of regularly ovate form, enlarged to four diameters.
Figs. 8-11. Dorsal, front, ventral and lateral views of a somewhat larger specimen, similarly enlarged, showing the usual features of the species.

RHYNCHONELLA INDIANENSIS, *Hall.*

Page 306.

Fig. 12. Dorsal view of a small specimen.
Figs. 13. 14. Dorsal and ventral views of a larger specimen, having three plications elevated on the dorsal fold.
Figs. 15, 16. Corresponding views of a specimen with four plications elevated on the dorsal fold.
Figs. 17, 18. The dorsal and ventral sides of a smaller specimen, having four plications on the fold.
Fig. 19. Lateral view of the specimen fig. 15.
Fig. 20. Lateral view of the specimen fig. 17.
Figs. 21, 22. Front views of the specimens figs. 15 and 17.

RHYNCHONELLA WHITII, *Hall.*

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Figs. 23-26. Dorsal, ventral, front and lateral views of a characteristic specimen of this species, having but two plications elevated in the center.
Figs. 27-29. Dorsal, ventral and front views of a specimen with one of the median plications divided, making three elevated on the mesial fold.
Figs. 30-33. Front, lateral, dorsal and ventral views of a specimen, showing four elevated plications on the mesial fold.

RHYNCHONELLA STRICKLANDI, *Sowerby.*

Page 308.

Figs. 34, 35. Dorsal and ventral views of a specimen of the more finely plicated variety.
Fig. 36. Dorsal view of a specimen with coarser plications.
Fig. 37. Lateral view of the specimen fig. 34.
Fig. 38. Front view of the preceding, showing the narrower form of the mesial elevation.

NIAGARA GROUP.

PLATE 26.

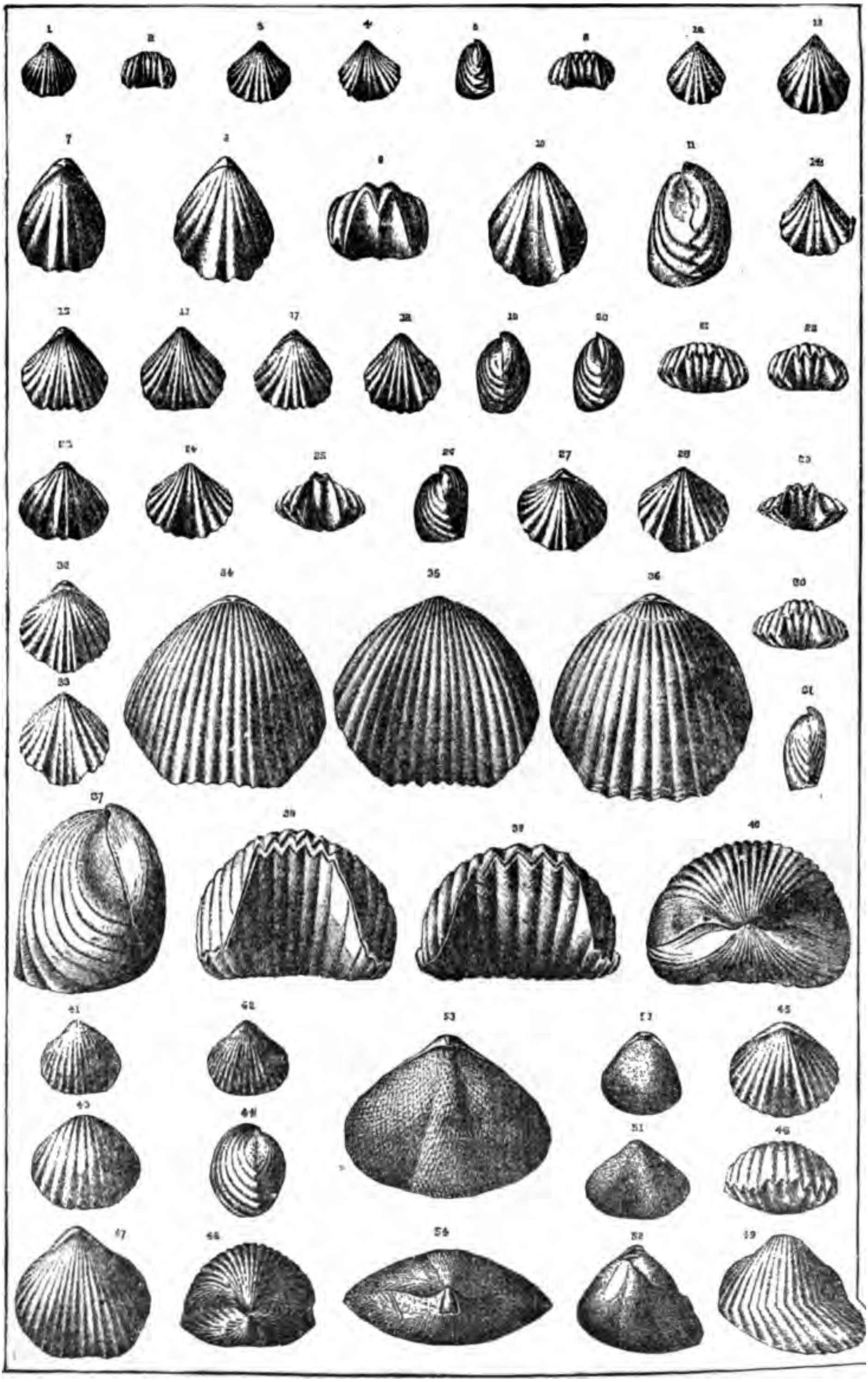

PLATE 26—(Continued.)

Fig. 39. Front view of the specimen fig. 36, showing a broader elevation than the last figure.

Fig. 40. Cardinal view of the more finely plicated variety.

ANASTROPHIA INTERNASCENS, *Hall.*

Page 311.

Figs. 41, 42. Ventral and dorsal views of a small specimen, more finely plicated than usual.

Figs. 43-46. Ventral, lateral, dorsal and front views of a specimen of medium size, having coarse plications.

Figs. 47-49. Dorsal, cardinal and ventral views of a specimen of the usual character.

EICHWALDIA RETICULATA, *Hall.*

Page 312.

Fig. 50. Dorsal valve of a narrow, elongate form, with a scarcely distinguishable mesial fold.

Fig. 51. Ventral side of a larger and more transverse specimen, showing a distinct mesial depression.

Fig. 52. A large imperfect specimen, intermediate in form between the two preceding, and with more distinctly defined mesial fold.

Figs. 53, 54. Dorsal and cardinal views of a specimen similar to fig. 51. enlarged, showing the surface characters, and (on the latter figure) the denuded space on the beak of the ventral valve, corresponding to the foramen in other genera.

These figures are copied from the *Twentieth Report on the N. Y. State Cabinet of Natural History*, page 275, and from *Pal. N. Y.*, Vol. IV, Part II (unpublished).

PLATE 27.

CRANIA SPINIGERA, *Hall.*

Page 283.

Fig. 1. The dorsal valve as attached to the surface of *Rhynchonella Stricklandi.*

LINGULA GIBBOSA, *Hall.*

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Fig. 2. Ventral valve of a specimen of this species.

RHYNCHONELLA NEGLECTA, *Hall.*

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Fig. 3. Dorsal view of a specimen showing the fewest and simplest plications which have been observed in any individual of this species among the extensive collections.

RHYNCHONELLA INDIANENSIS, *Hall.*

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Figs. 4, 5, 6. Three specimens representing extreme phases of variation in this species, differing from those shown in the figures of the species on plate 26.

ZYGOSPIRA MINIMA, *Hall.*

Page 305.

Fig. 7. Dorsal view of the specimen as three times enlarged.

SPIRIFERA BICOSTATA? *var.* PETILA, *Hall.*

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Fig. 8. Dorsal view of a large specimen, natural size.

Fig. 9. Cardinal view, showing the area, and convexity of the valve, enlarged three diameters.

MERISTELLA RECTIROSTRA, *Hall.*

Page 301.

Figs. 10, 11, 12. Dorsal, ventral, and profile view of a representative specimen.

Fig. 13. Dorsal view of an individual which is more elongate than usual.

Fig. 14. A specimen showing the size and direction of the spires.

PENTAMERUS FORNICATUS, *var. Hall.*

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Fig. 15 View of the only specimen observed.

NIAGARA GROUP

PLATE 27.

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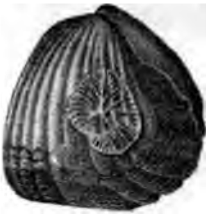

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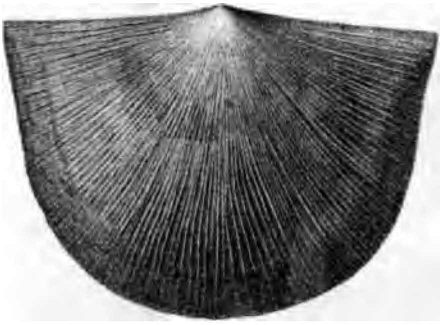

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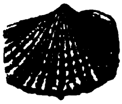

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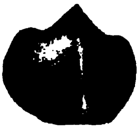

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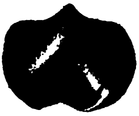

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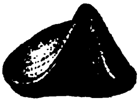

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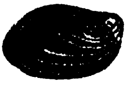

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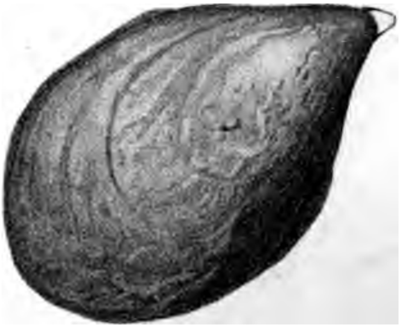

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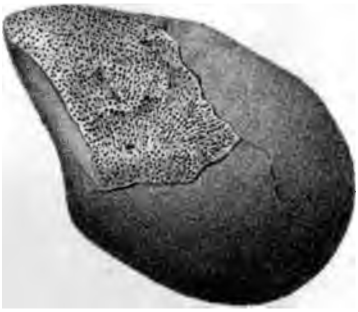

Emmons, del.

Wm.B.Burford, Lith. Indianapolis

PLATE 27—(Continued.)

ORTHIS BILOBA, *Linn.*

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Fig. 16. Ventral valve, twice enlarged.

ORTHIS SUBNODOSA, *Hall.*

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Fig. 17. Ventral valve showing the nodose character of the plications.

STROPHODONTA PROFUNDA, *Hall.*

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Fig. 18. A large entire ventral valve showing the normal characters of the species.

TRIPLESIA PUTILLUS, *Hall.*

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Figs. 19–22. Four views of a specimen from this species enlarged to three diameters.

CYPRICARDINIA ARATA, *Hall.*

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Fig. 23. The interior of a compressed left valve showing the strong concentric lamellæ.

PTERINEA BRISA. *Hall.*

Page 316.

Fig. 24. A portion of the surface of a large specimen, natural size, showing the lamellæ and the semi-tubular spines of the ornamentation.

Fig. 25. A profile showing the curvature of the lamellæ.

GONIOPHORAS SPECIOSAS, *Hall.*

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Fig. 26. The left valve showing the form of the valve and the angular posterior slope.

Fig. 27. Cardinal view showing the convexity of the valves.

AMBONYCHIA ACUTIROSTRA, *Hall.*

Page 314.

Fig. 28. The right valve showing the form of the valve, and a few obscure concentric lamellæ of growth.

Fig. 29. A left valve which is partially covered with an expansion of *Sagenella elegans.*

PLATE 28.

AMPHICŒLIA LEIDYI, *Hall.*

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Fig. 1. An imperfect left valve.

Fig. 2. An imperfect right valve, which presents some difference in the form and position of the beak; probably indicating a distinct species.

MODIOLOPSIS PERLATUS, *Hall.*

Page 315.

Fig. 3. A right valve characteristic of the species.

Fig. 4. Cardinal view of the same, showing the convexity of the valve.

MODIOLOPSIS SUBALATUS, *Hall.*

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Fig. 5. The left valve of a form closely resembling the *M. subalatus* of New York, but of larger dimensions.

Fig. 6. A right valve, having a proportionally greater length; in this feature more nearly approaching the New York species.

PTERINEA BRISA, *Hall.*

Page 316.

Fig. 7. The exterior of a small, imperfect left valve, with well-preserved surface characters.

Fig. 8. The interior of a large, imperfect left valve.

Fig. 9. An internal cast of a small left valve.

MYTILARCA SIGILLA, *Hall.*

Page 316.

Fig. 10. A small right valve of a specimen of this genus.

ORTHOCERAS SIMULATOR, *Hall.*

Page 322.

Fig. 11. A fragment of the septate portion of a specimen, showing its general form and character.

Fig. 12. A smaller fragment, similar to the last, but apparently retaining the exterior shell over a portion of the tube.

TROCHOCERAS WALDRONENSIS, *Hall.*

Page 326.

Fig. 13. Lateral view of a specimen preserving one volution, and showing the annulations, but no septa.

Fig. 14. Ventral view of the same showing the compressed condition of the specimen, and the sinus in the annulations on the ventral side.

Fig 15. Lateral view of a specimen preserving about the same extent of the tube, with the annulations less distinct, and showing no septa.

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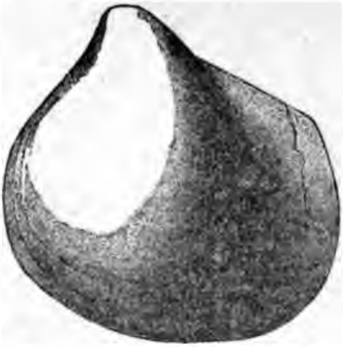

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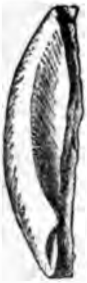

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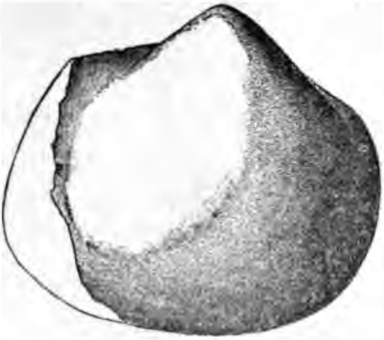

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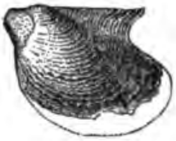

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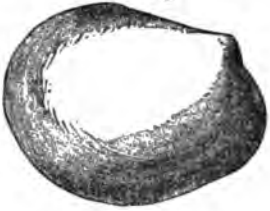

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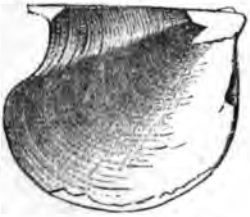

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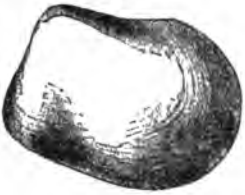

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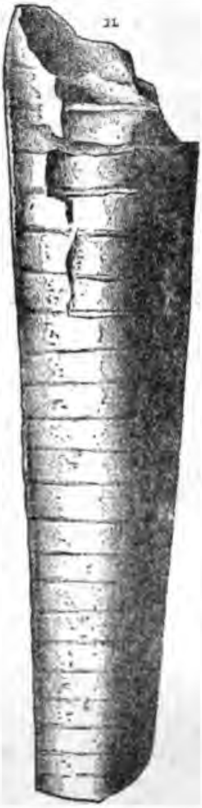

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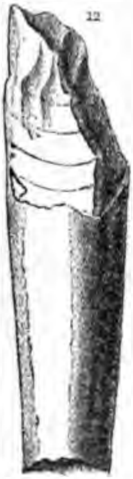

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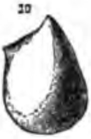

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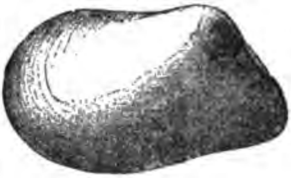

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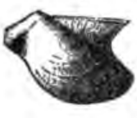

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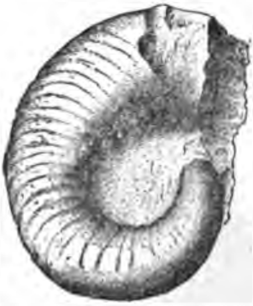

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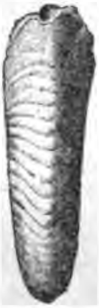

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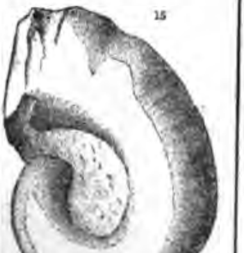

PLATE 29.

PLATYOSTOMA NIAGARENSE, *Hall.*

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Fig. 1. A small specimen, showing strong revolving striæ and with a slight depression on the upper surface of the last volution.

Figs. 2–4. Basal, summit and lateral views of a specimen similarly striated, which is sulcated above and below, with two distinct folds on the lower surface of the volution.

Figs. 5–7. Three views of a larger, loosely coiled specimen, with a distinct sulcation above and below the middle of the volution.

Figs. 8, 9. Two views of a more ventricose specimen with regularly convex volutions.

Figs. 10, 11. The summit and ventral view of a large loosely coiled specimen, the outer volution being free.

Fig. 12. The spire of a large ventricose specimen, with closely coiled volutions.

PLATYOSTOMA NIAGARENSE?

Page —.

Fig. 13. A specimen with its aperture showing a twisted inner lip of the peristome. This feature is produced by the folds on the inner part of the volution and is not a true columella.

PLATYOSTOMA PLEBIUM, *Hall.*

Page 319.

Figs. 14, 15. The opposite sides of a specimen, showing the height of the spire and form of the volution and aperture.

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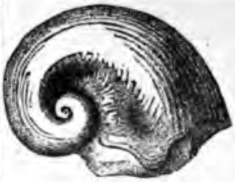

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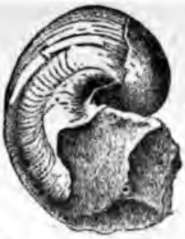

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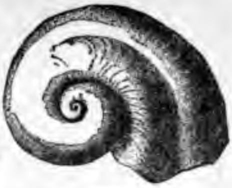

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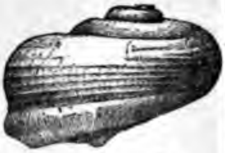

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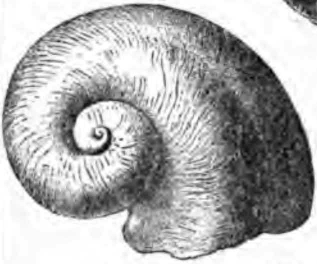

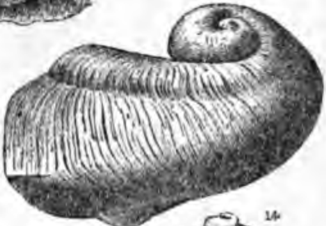

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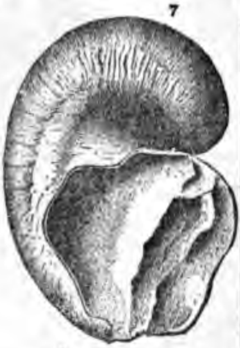

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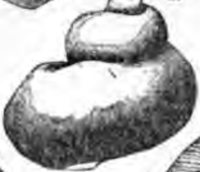

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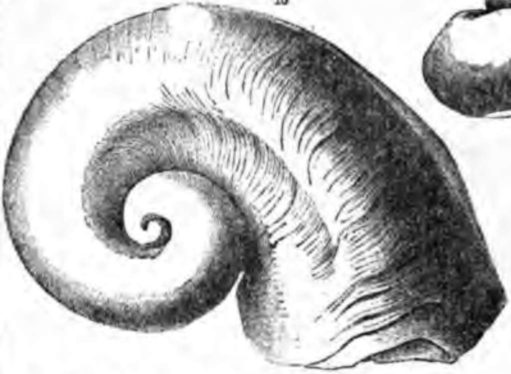

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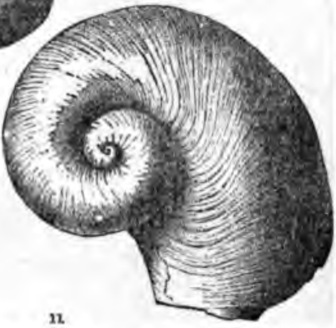

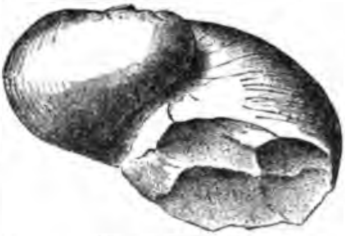

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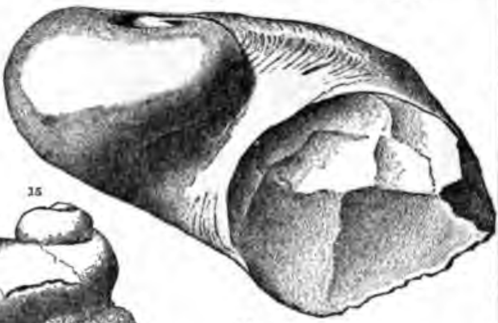

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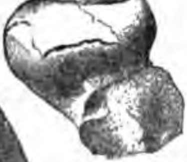

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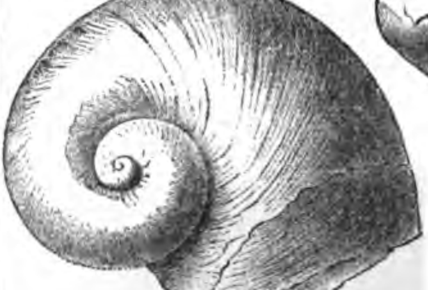

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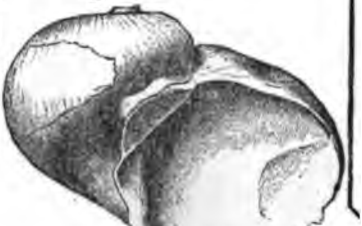

PLATE 30.

PLATYOSTOMA NIAGARENSE, *Hall.*

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Figs. 1-4. Four views of a specimen of medium size, where the inner lip of the peristome unites with the surface of the preceding volution, with the spire rising but little above the level of the outer part of the shell.

Fig. 5. The aperture of a specimen having the spire flat or slightly depressed, and the peristome spreading upon, and conforming to the shape of the preceding volution.

Fig. 6. The aperture of a larger specimen, with more rounded volutions and elevated spire, but having the peristome overlapping the preceding volution.

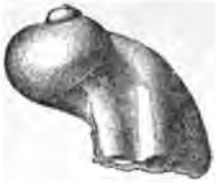
Figs. 7-10. Four views of a specimen with moderately elevated spire, subdepressed volutions and slightly united peristome. In consequence of some accident during the early stages of growth, the inner part of the lower lip has become contracted, forming a deep and abrupt break in the margin, which has probably increased with the age of the shell; as shown in fig. 9.

Figs. 11-13. Front, dorsal and basal views of a slender, depressed specimen, with loosely coiled volutions, which become disunited and deflected.

Figs. 14, 15. The opposite sides of a large ventricose specimen, with rapidly increasing volutions—the last one becoming disunited and deflected, presenting a very peculiar character, and wide contrast with other forms.

NIAGARA GROUP.

11



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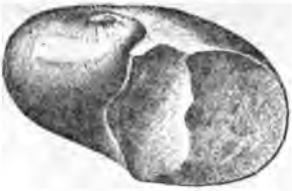

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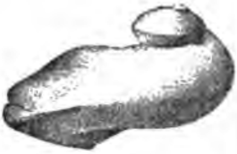

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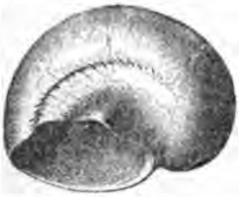

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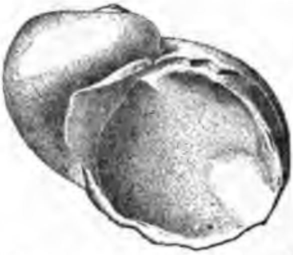

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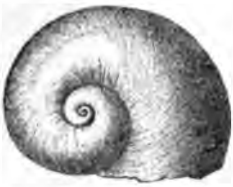

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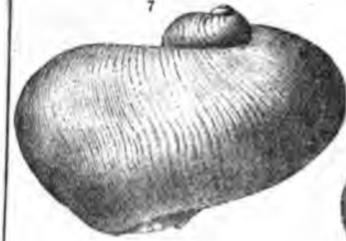

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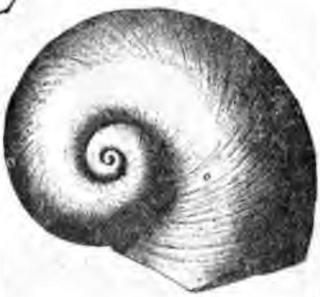

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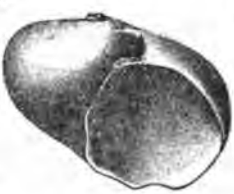

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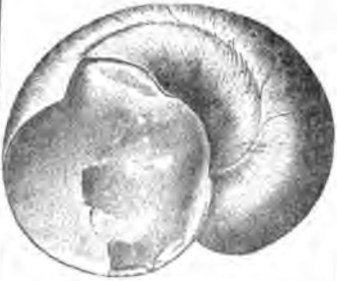

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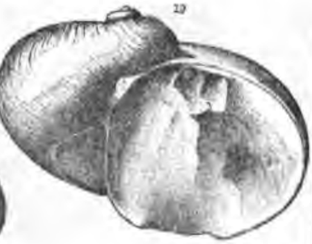

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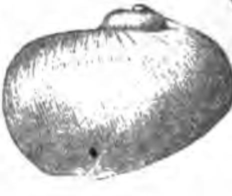

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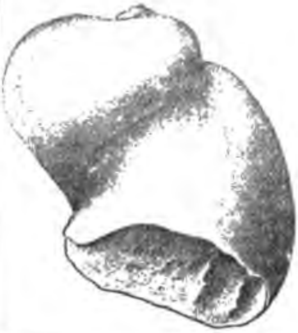

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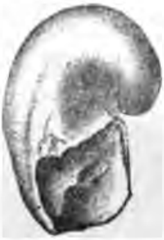

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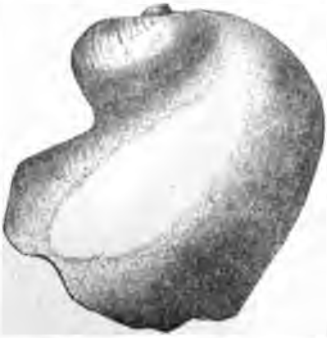

PLATE 31.

STROPHOSTYLUS CYCLOSTOMUS, *Hall*,

Page 319.

Fig. 1. The back of a small specimen, showing the rotundity of the volutions and an unusually high spire.

Fig. 2. An oblique front view of a larger characteristic specimen, showing the obliquity of the aperture.

Figs. 3, 4. Summit and lateral views of a specimen of usual form and size.

Fig. 5. The aperture of a more elevated specimen, showing the character of the inner lip and columella.

Fig. 6. Dorsal view of a specimen with very rotund volutions.

Fig. 7. The aperture of a more erect and elevated form, showing some slight differences from fig. 5.

Figs. 8-10. Dorsal, basal and oblique front views of a large perfect specimen, showing the direction of the striæ, the aperture, etc.

Figs. 11, 12. Front and oblique lateral veiws of a specimen showing the form of the aperture, inner lip, and twisting of the columella.

Fig. 13. An enlargement of the surface-striæ of a full-grown specimen, showing the transverse striæ of growth, and the finer revolving lines.

STROPHOSTYLUS CYCLOSTOMUS *var.* DISJUNCTUS, *Hall.*

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Figs. 14, 15. The opposite sides of a specimen referred with doubt to this species. The outer volution has become free, so that its generic characters are obliterated; but the surface-striæ and the upper volutions are precisely the same as *S. cyclostomus*.

CYRTOLITES SINUOSUS, *Hall.*

Page 321.

Figs. 16-18. Lateral, front and dorsal views of a specimen enlarged to three diameters.

BELLEROPHON TUBER, *Hall.*

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Figs. 19, 20. Dorsal and lateral views of a specimen, enlarged to two diameters.

NIAGARA GROUP.

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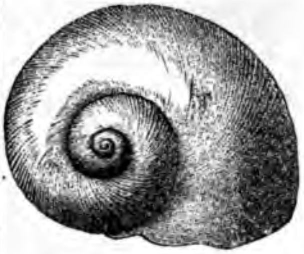

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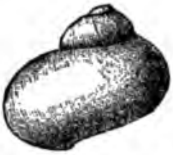

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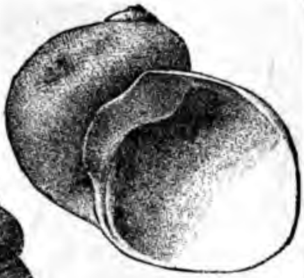

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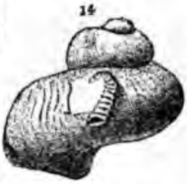

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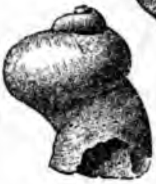

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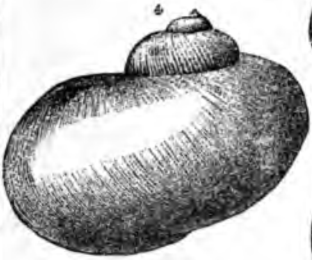

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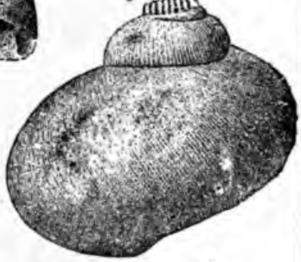

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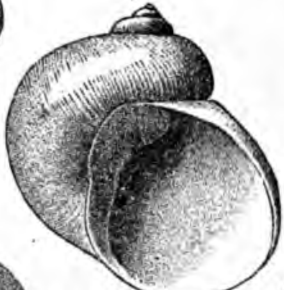

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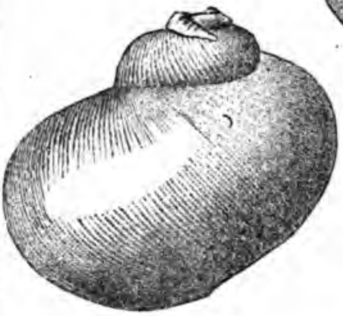

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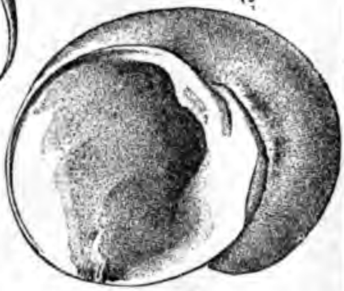

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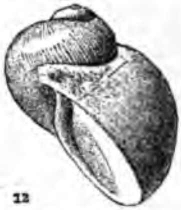

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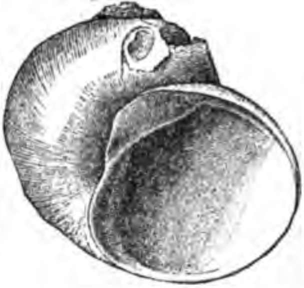

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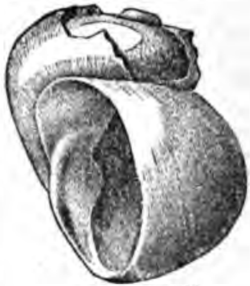

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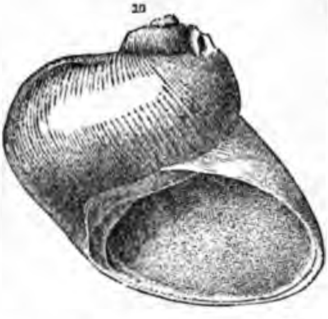

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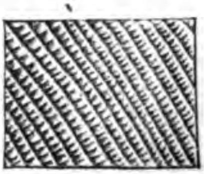

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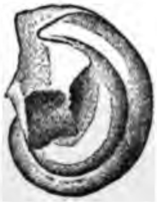

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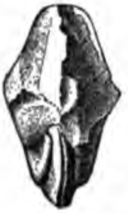

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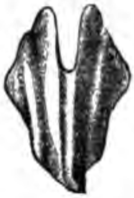

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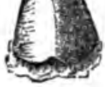

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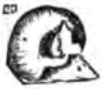

PLATE 32.

CORNULITES PROPRIUS, *Hall.*

Page 327.

Fig. 1. A group of young individuals attached to a young shell of *Strophostylus cyclostomus*, enlarged to two diameters. This group has the peculiarity of forming an irregular circle—the only instance of this kind observed.

Fig. 2. A large specimen attached to a shell of the same species as above.

Fig. 3. A group of three individuals of different sizes attached to the shell of *Platyostoma Niagarense*.

Fig. 4. Lateral view of a large specimen, showing the usual characters of the fully developed form.

Fig. 5. A smaller specimen which is attached to the side of the cup of *Eucalyptocrinus crassus*. The attached portion of the tube is flattened on the lower side and thickened above, and united by nearly its entire width to the crinoidal plates.

Fig. 6. A specimen of very irregular growth and strongly striated surface.

Fig. 7. Lateral view of a similar specimen, showing, as in the preceding the repairs of injuries received during life.

Fig. 8. An enlargement of the surface, showing the character of the longitudinal striæ, and the abrupt change at one of the concentric ridges.

Fig. 9. A longitudinal section of a large imperfect specimen, showing the cellulose texture of the substance, and also the annulated character of the interior face of the tube.

Fig. 10. A longitudinal section of a large specimen, where the walls have been quite thin, showing the annulation of the inner surface and a thin coating of cellulose tissue, chiefly on one side.

Fig. 11. A transverse section of a specimen enlarged, showing the vesicular texture of the test.

Fig. 12. A still farther enlargement from the same specimen.

Fig. 13. An enlargement of a part of the left side of specimen fig. 9, near the middle of the length, showing the partial obliteration of the annulations, on the interior at this point, by the formation of vesicular tissue upon the inner face. This change is probably the result of thickening and contracting the space with the advancing age of the individual; the usual and almost invariable mode of increase being by exterior additions of tissue.

Forms like those represented in figures 1, 2 and 3, have sometimes been referred to Cornulites, Tentaculites, and to column bases of Cystidians. More recently Prof. Nicholson has proposed the names Ortonia and Conchicolites for similar forms. The absolute connection of these small annulated forms with the larger ones, like figures 4, 5, 6 and 7, has been demonstrated; and we find the smaller attached forms, where there has been a thickening of the exterior, and a partial obliteration of the regular annulations, giving the individuals the aspect of the bases of figures 4 and 5. Moreover, longitudinal sections of these small annulated forms show vesicular structures similar to the larger ones. In one example, the

NIAGARA GROUP.

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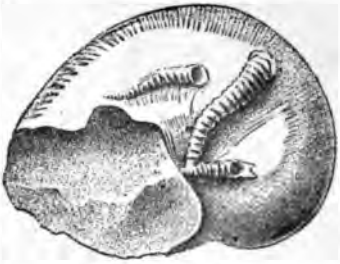

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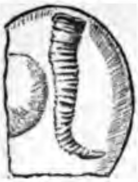

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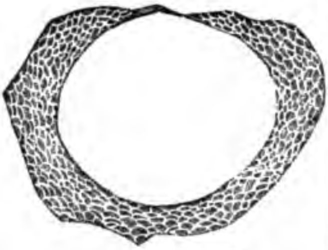

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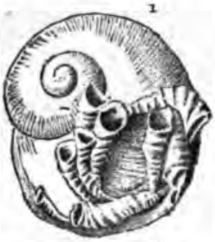

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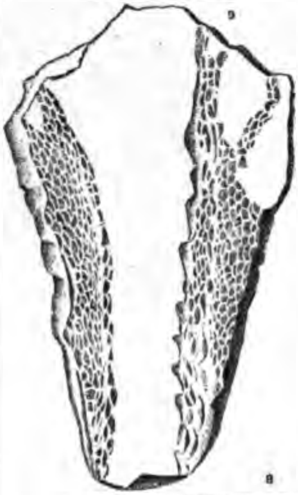

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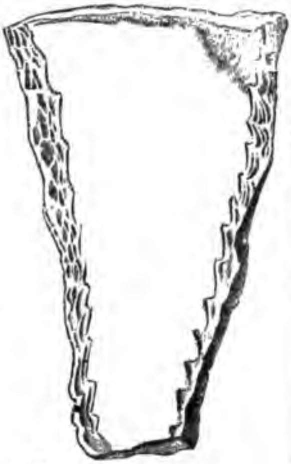

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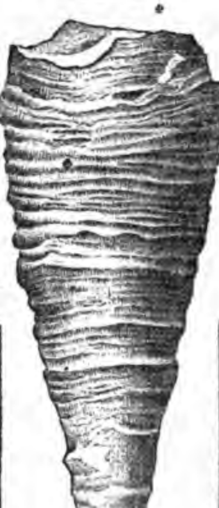

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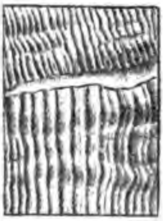

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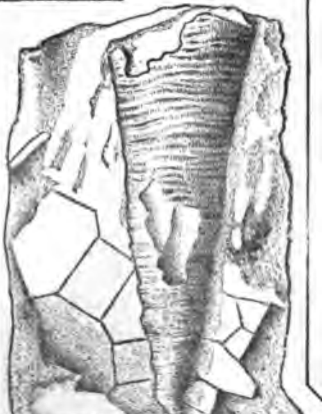

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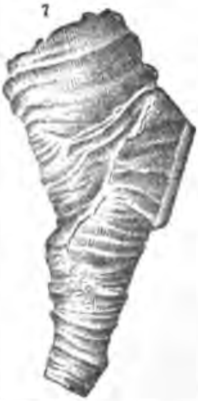

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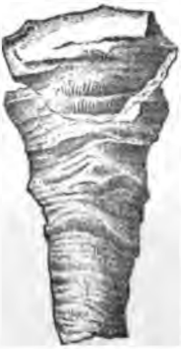

PLATE 32—Continued.

interior wall of the tube is well marked with an exterior thickening of loose texture; and in another specimen, the inner wall is similarly well-defined, with an exterior thickening of the substance which is distinctly vesicular in structure.

SPIRORBIS INORNATUS, *Hall.*

Page 327.

Fig 14. A group of these specimens, natural size, attached to the surface of a *Strophomena.*

Fig. 15. A specimen enlarged, to show the character of the shell, and the incipient annulations.

PLATE 33.

ORTHOCERAS SIMULATOR, *Hall.*

Page 322.

Fig. 1. An individual preserving the chamber of habitation entire and a large portion of the air-chambers. The appearance of an organic deposit near the apex is due to the filling of iron pyrite.

Fig. 2. Transverse section showing the form of the tube and the position of the siphuncle.

ORTHOCERAS AMYCUS, *Hall.*

Page 324.

Fig. 3. A fragment of the septate portion showing the depth of the air-chambers and the annulations and ornamentation of the test.

Fig. 4. A septum showing the transverse section of the tube and the position of the siphuncle.

ORTHOCERAS SUBCANCELLATUM, *Hall.*

Page 323.

Fig. 5. A septate fragment showing the depth of the air-chambers and the ornamentation of the tube.

BELLEROPHON TUBER, *Hall.*

Page 320.

Fig. 6. Dorsal view showing the expanded aperture and sinus in the dorsal margin.

CONULARIA INFREQUENS, *Hall,*

Page 321.

Fig. 7. An impression of a portion of the test as preserved in the soft shale, showing the character of the ornamentation in reverse.

COLEOLUS SPINULUS, *Hall.*

Page 322.

Fig. 8. A specimen three times enlarged, showing the fine concentric striæ.

DALMANITES VIGILANS, *Hall.*

Page 339.

Fig. 9. A specimen preserving the thorax nearly entire, and showing the general form of the species.

NIAGARA GROUP

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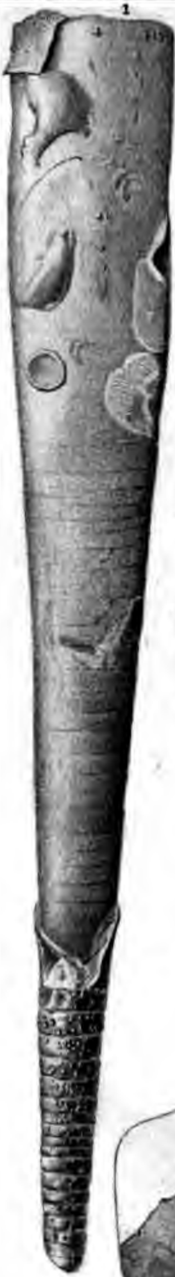

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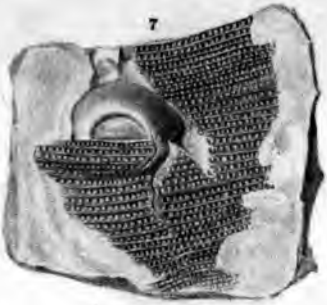

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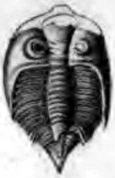

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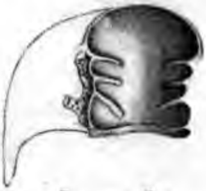

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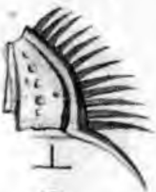

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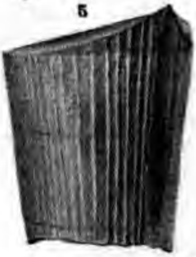

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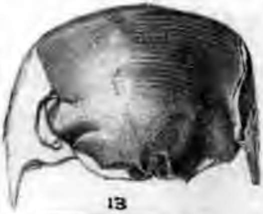

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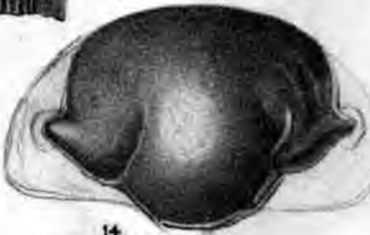

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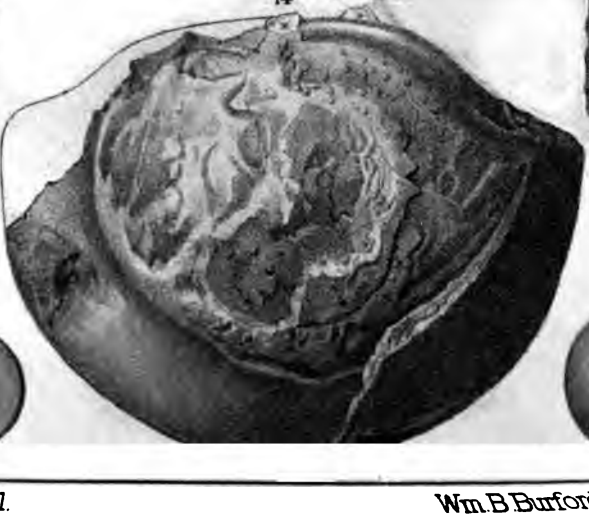

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Wm.B.Burford, Lith. I

PLATE 33—Continued.

CERAURUS NIAGARENSIS, *Hall.*

Page 335.

Fig. 10. The glabella with a portion of the left cheek, and the remainder of this side of the head completed in outline.

ACIDASPIS FIMBRIATA, *Hall.*

Page 334.

Fig. 11. The under side of a separate left cheek, showing the marginal spines. Enlarged four diameters.

ILLÆNUS ARMATUS, *Hall.*

Page 335.

Fig. 12. An imperfect head preserving the right movable cheek with its posterior extension into a spine.

ILLÆNUS (BUMASTUS) IOXUS, *Hall.*

Page 335.

Fig. 13. The glabella of this species.
Fig. 14. A large pygidium referred to in the description.

PLATE 34.

LEPERDITIA FABA, *Hall.*

Page 331.

Fig. 1. The right side of a specimen greatly enlarged, showing the line of the hinge and the projection of the left valve above the right.

Fig. 2. Basal view of the same specimen, showing the convexity of the valves.

Fig. 3. The left side of a specimen, showing the overlapping of the valves at the base.

BEYRICHIA GRANULOSA, *Hall.*

Page 331.

Fig. 4. An enlargement of a right valve with the dorsal margin incomplete, showing the general form and granulose surface. The granulæ as represented are too regularly disposed.

CYPHASPIS CHRISTYI,* *Hall.*

Page 333.

Fig. 5. A separate head, imperfect on the eye-tubercles and the glabella, enlarged to two diameters.

Fig. 6. An entire individual, enlarged to two diameters.

Fig. 7. Profile of the same specimen, showing the elevation of the body, enlarged to correspond with the preceding figure.

CALYMENE NIAGARENSIS, *Hall.*

Page 331.

Fig. 8. The upper surface of a large specimen, slightly distorted about the cephalic shield.

Fig. 9. The under side of the same, showing the hypostoma in place.

Fig. 10. The upper surface of a larger cephalic shield, showing nearly perfect eye-tubercles.

Figs. 11, 12. Front and lower side of the same specimen, showing the continuation of the facial sutures.

Fig. 13. A separated glabella and fixed cheeks.

Fig. 14. Profile of the specimen fig. 11.

Fig. 15. Profile of the specimen fig 13, showing the line of the facial suture and elevation.

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*Page 333, for Chrystyi read Christyi.

NIAGARA GROUP.

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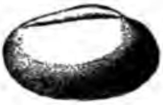

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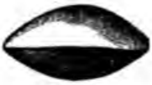

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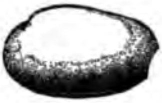

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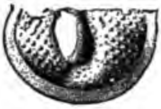

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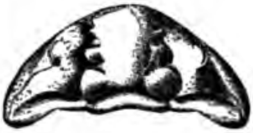

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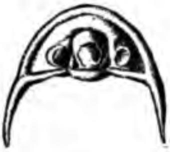

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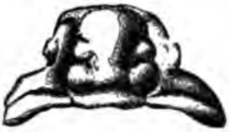

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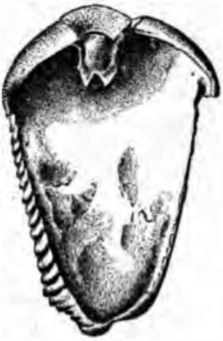

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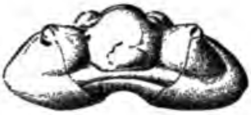

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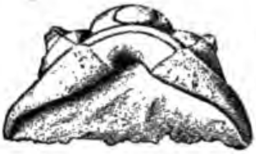

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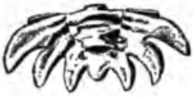

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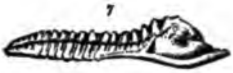

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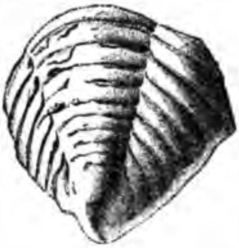

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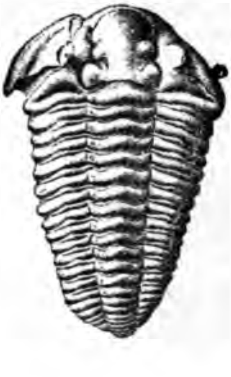

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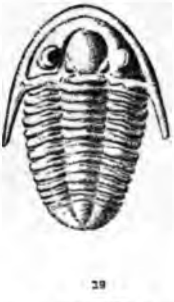

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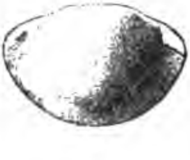

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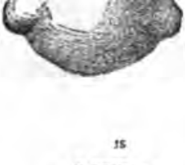

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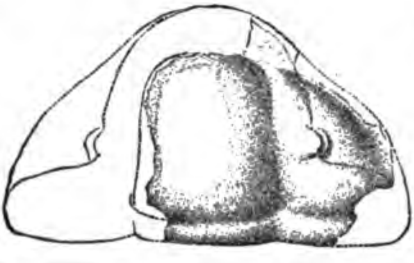

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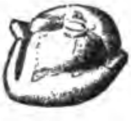

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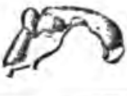


PLATE 34—Continued.

CERAURUS (CHIERURUS) NIAGARENSIS, *Hall.*

Page 335.

Fig. 16. A nearly entire pygidium, showing its form and characters.

HOMALONOTUS DELPHINOCEPHALUS, *Green.*

Page 332.

Fig. 17. The upper surface of a fragment of a head, showing the characters as well as can be seen in any of the specimens known from this locality.

Fig. 18. An imperfect pygidium.

ILLÆNUS ARMATUS, *Hall.*

Page 335.

Fig. 19. An imperfect glabella.

Fig. 20. An imperfect pygidium, the anterior margin restored in outline at the right hand upper angle.

PLATE 35.

DALMANITES VIGILANS, *Hall.*

Page 339.

Fig. 1. The upper side of a cephalic shield, showing the characters observed on several individuals from this locality.

Fig. 2. The lower surface of the border of a head.

Figs. 3, 4. Two pygidia referred to the same species.

DALMANITES VERRUCOSUS, *Hall.*

Page 341.

Fig. 5. A small head, having the usual character of this species.

Fig. 6. A larger head showing a slight spiniform node on the occipital ring.

Fig. 7. The dorsal surface of a large specimen, preserving the head and thorax entire, and the anterior part of the pygidium, with all their characteristic markings.

Fig. 8. A much larger imperfect head.

Fig. 9. Anterior view of a nearly perfect head, of somewhat more than the medium size, showing the anterior extension of the facial suture, on the left hand side of the figure.

Fig. 10. Lateral view of the same, showing the posterior extension of the facial suture.

Fig. 11. An enlargement of the eye.

Fig. 12. A profile view of a thoracic segment.

Figs. 13–15. The pygidia of three individuals, showing gradations in size.

Fig. 16. Profile of the specimen fig. 15, showing the elevation of the axis.

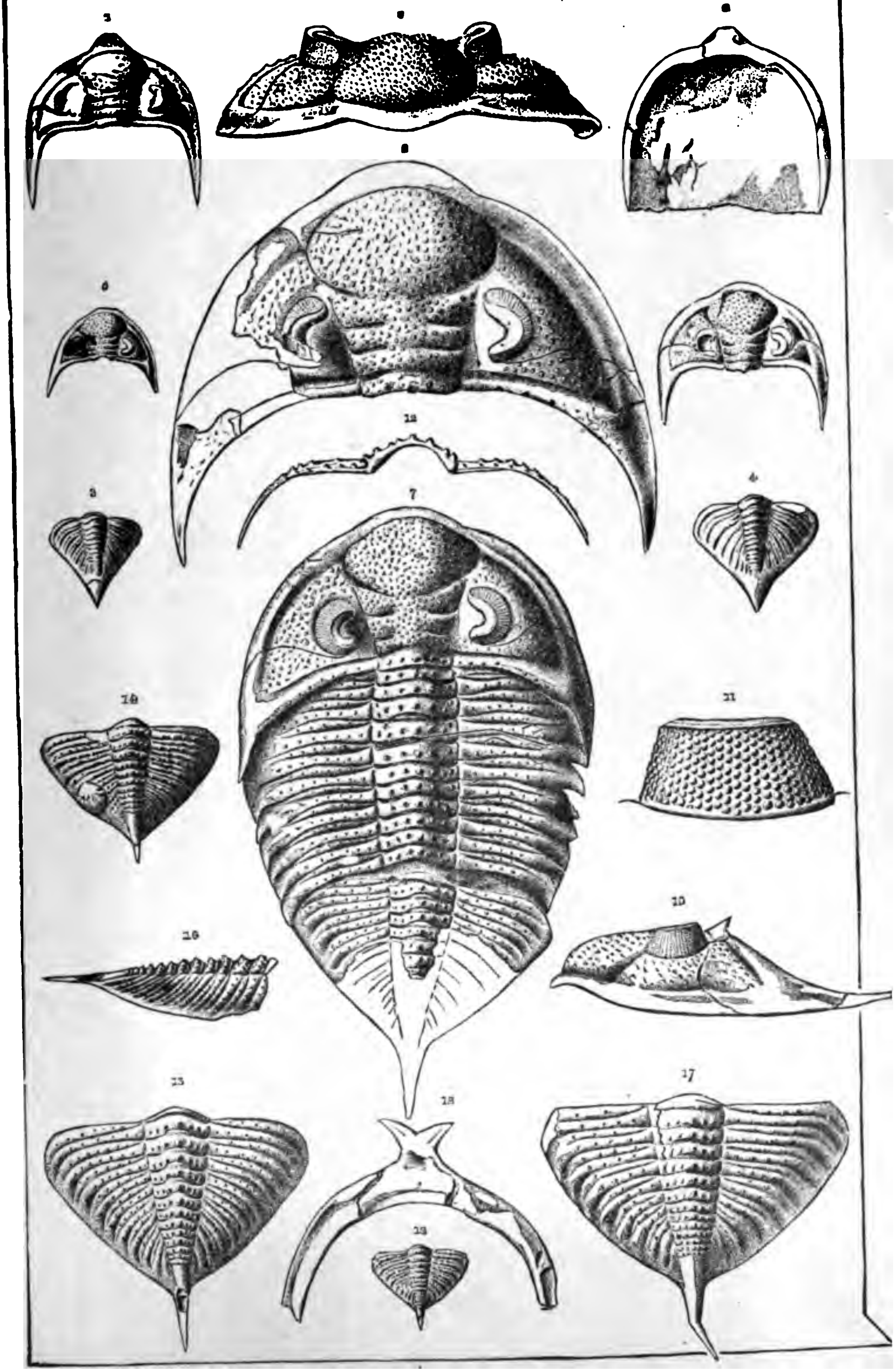
Fig. 17. A larger pygidium, which is remarkably straight on the anterior margin.

DALMANITES BICORNIS, *Hall,*

Page 342.

Fig. 18. The lower surface of the marginal rim of the head, showing the anterior bifurcating process. No other parts of this species are known at the present time.

NIAGARA GROUP.



36—Geol.

PLATE 36.

LICHAS BREVICEPS. *Hall.*

Page 343.

Fig. 1. The upper surface of an imperfect head; the typical form of the species.

Fig. 1a. An enlargement of the surface of the glabella.

Fig. 2. Profile view of the same, showing the elevation of the glabellar lobe.

Fig. 3. An enlargement of the eye.

Fig. 4. An imperfect thorax and pygidium; the anterior part of the figure is restored in outline.

Fig. 5. The lower surface of a large imperfect pygidium, showing the striæ of the enfolded border.

Fig. 6. The upper surface of a smaller imperfect pygidium, restored in outline.

Fig. 7. The central portion of a large glabella; the outline is carried out to correspond with the specimen fig. 1.

LICHAS BOLTONI (*Bigsby*) *var.* OCCIDENTALIS, *Hall.*

Page 344.

Fig. 8. The lower side of a large perfect pygidium, showing the broad inner lining of the border with its characteristic markings.

Fig. 9. The upper side of a smaller imperfect pygidium. The separation between the lobe of the axis and its continuation on the marginal expansion, is due to accidental pressure and partial distortion of the parts.

Fig. 10. The lower surface of a smaller pygidium, showing similar characters to fig. 8, except that it is more rounded on the posterior margin.

Fig. 11. The hypostoma of a specimen, probably of this variety, resembling those from the Niagara shale of New York.

Fig. 12. The anterior extension of a head of undetermined specific relations belonging to this genus.

DALMANITES VERRUCOSUS, *Hall.*

Page 341.

Fig. 13. The lower surface of the marginal rim of the head, for comparison with fig. 2 of pl. 33.

Fig. 14. The inner side of the crust of a pygidium, showing the points of attachment for natatory organs.

Fig. 15. Profile view, looking across the elevation of these processes of attachment, and of the ridge corresponding to the dorsal furrow of the exterior.

NIAGARA GROUP.

PLATE 36.

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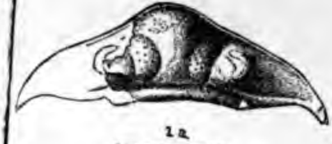

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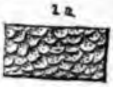

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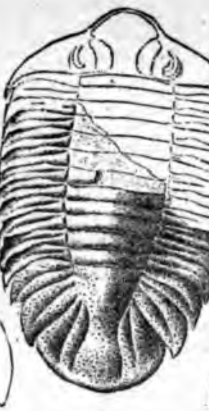

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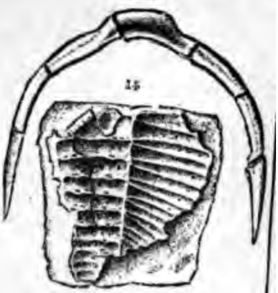

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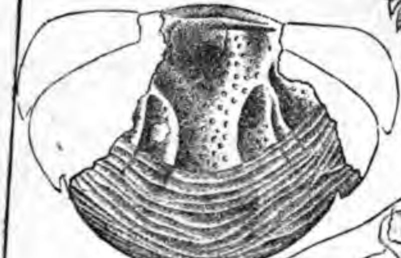

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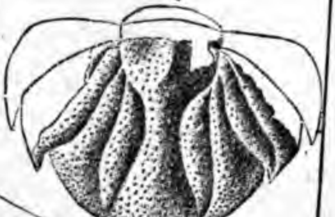

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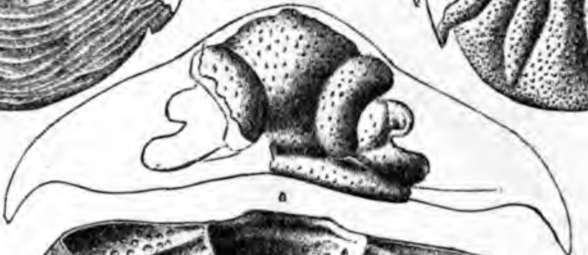

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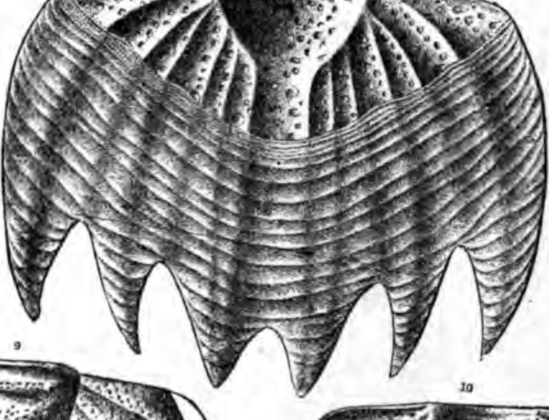

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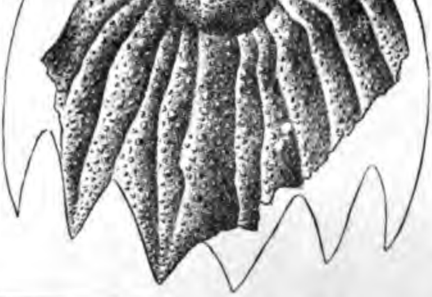

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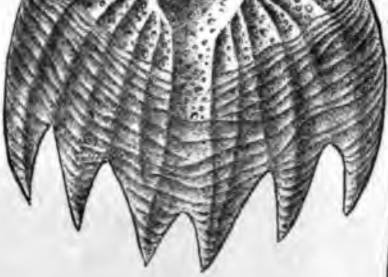
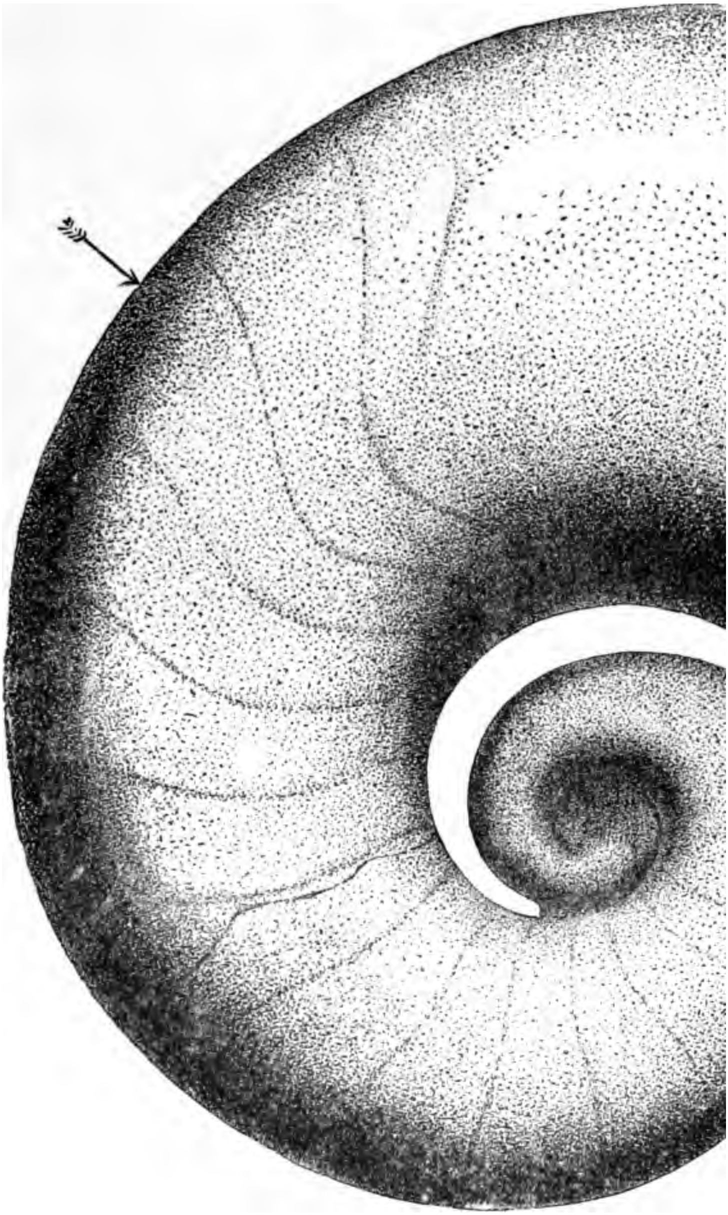


PLATE 37.

Gyroceras elrodi.

Page 356.

Fig. 1. Side view, natural size of the type specimen. See other figures on plate 38



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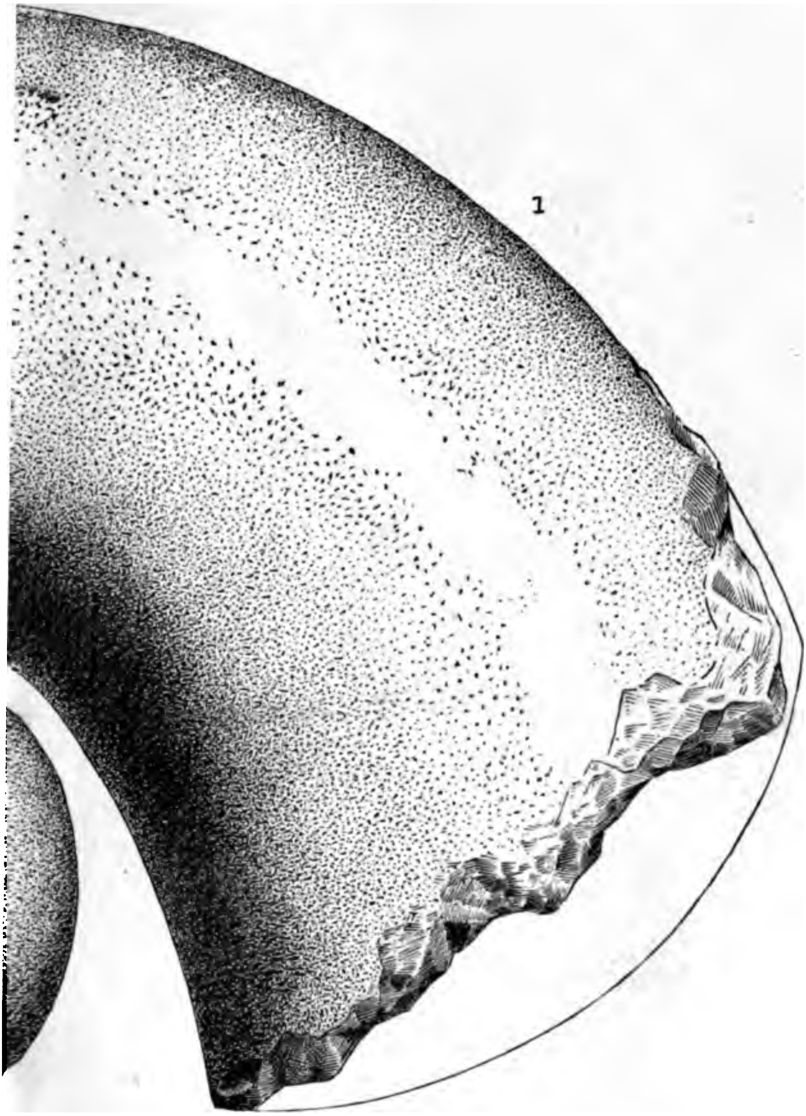
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PLATE 38.

ORTHOCERAS ANNULATUM.

Page 358.

Fig. 1. Fragment, natural size, showing surface markings, which are represented upon the figure a little stronger than natural.

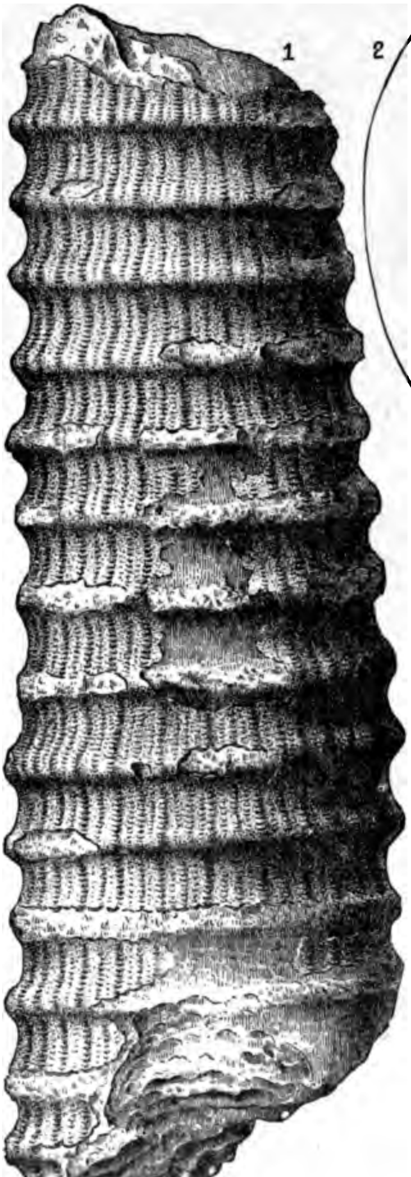
GYROCERAS ELRODI.

Page 356.

Fig. 2. Outline of transverse section, taken at the point indicated by the arrow on plate 37.

Fig. 3. Diagram, showing convexity of the septa and position of the siphuncle.

Fig. 4. Portion of surface showing revolving and transverse lines. See principal figure on plate 37.



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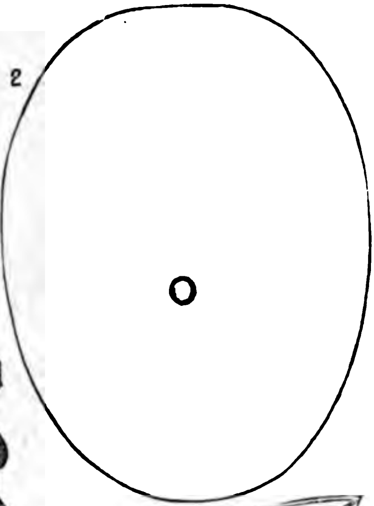

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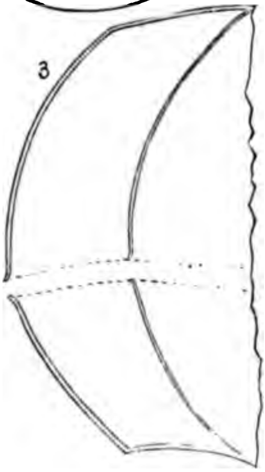

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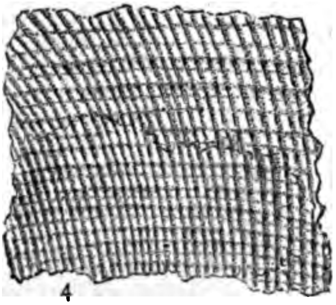

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From Pen Drawings by J. C. McConnell.

PLATE 39.*

CYATHOCRINUS MULTIBRACHIATUS.

Page 367.

Fig. 1. Side view of an example having the arms and portion of the stem attached.

ONYCHOCRINUS RAMULOSUS.

Page 366.

Fig. 2. View of anal side.

Fig. 3. Opposite view of the same. The arms remain in place, but the specimen has been compressed, the stem broken and a small part of it wanting.

PATELLA LEVETTEI.

Page 359.

Fig. 4. Upper view. The apex has evidently been broken off, and is not naturally perforate, as it appears to be in the figure.

Fig. 5. Lateral view of the same.

TEREBRATULA FORMOSA.

Page 361.

Fig. 6. Dorsal view of a moderately large example.

Fig. 7. Lateral view of the same.

Fig. 8. Ventral view of a larger example.

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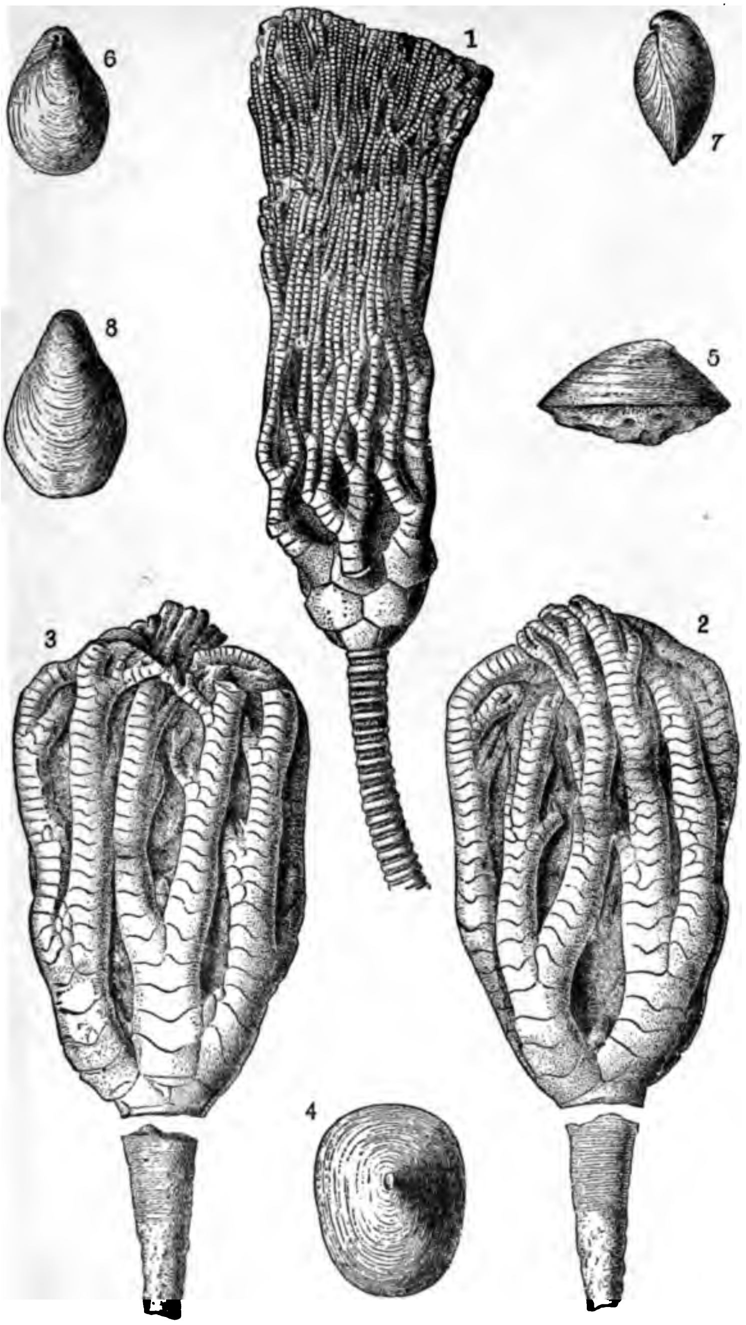
* All the figures on this plate are of natural size.

SUB-CARBONIFEROUS.

PLATE 39.



From Pen Drawings by J. C. McConnell.

PLATE 40.*

ONYCHOCRINUS EXSCULPTUS.

Page 365.

Fig. 1. Side view of a partially crushed and somewhat imperfect example, showing portion of stem and arms.

AGARICOCRINUS SPRINGERI.

Page 363.

Fig. 2. View of anal side of type specimen. The sub-spinous projections of the row of pieces which surround the anal area of the dome have been in part broken off.

Fig. 3. Lateral view of the same.

Fig. 4. Basal view of the same.

BELLEROPHON SUBLÆVIS.

Page 359.

Fig. 5. Apertural view.

Fig. 6. Lateral view of the same.

Fig. 7. Dorsal view of the same.

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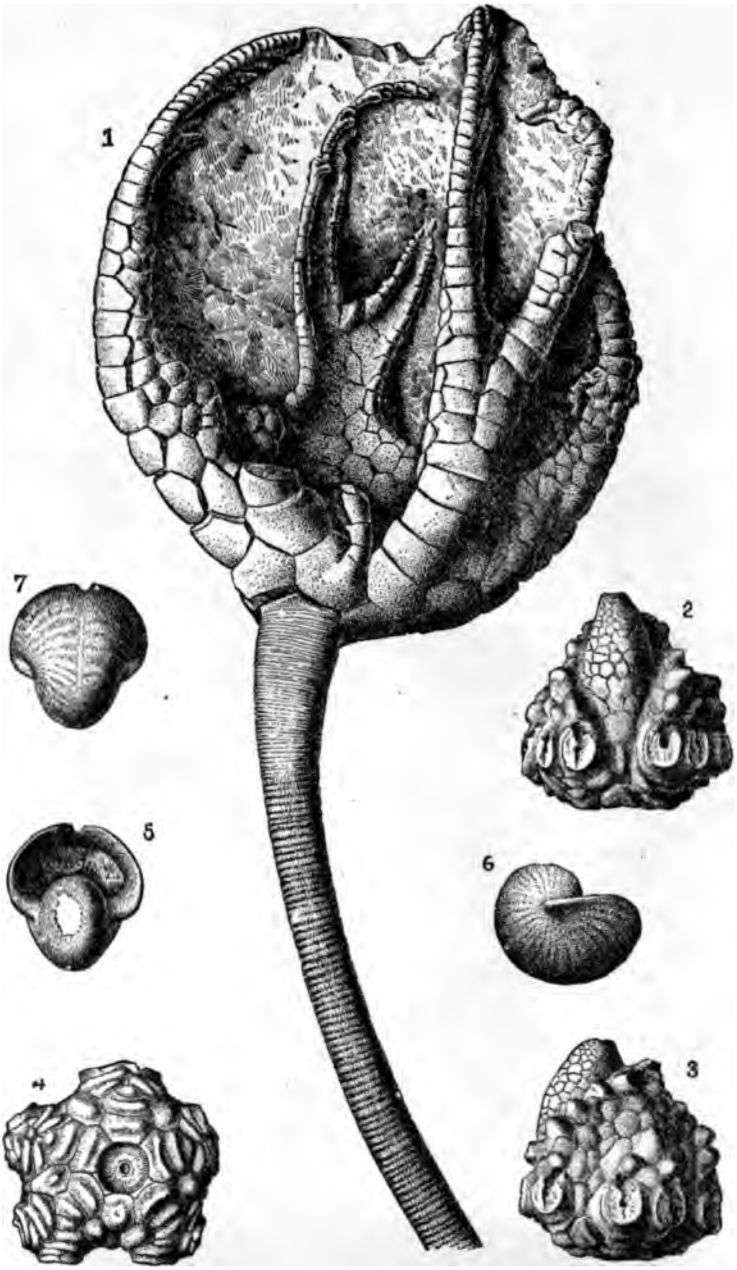
*All the figures on this plate are of natural size.



From Pen Drawings by J. C. McConnell.

PLATE 41.

PLATYCRINUS HEMISPHERICUS.

Page 368.

Fig. 1. Side view of an example with portion of the stem and arms attached.

LEPIDESTHES COLLETTI.

Page 362.

Fig. 2. Lateral view of the type specimen. The figure was inadvertently placed wrong end up when it was drawn, as is shown by the imbrication of the ambulacral pieces, natural size.

Fig. 3. Diagram of a single piece of the ambulacral series, with adjacent borders of two others, showing the position of the two pores, enlarged.

BELLEROPHON GIBSONI.

Page 360.

Fig. 4. Dorsal view of a natural cast of the interior of the shell.

Fig. 5. Opposite view of the same, showing the great thickness of the test between the inner and outer whorls.

Fig. 6. Lateral view of the same, all of natural size.

ARCHIMEDES LAXA.

Page 361.

Fig. 7. A portion of the axis only, the frond being all destroyed, but the first row of fenestrules appear upon the edge of the spiral portion; natural size.

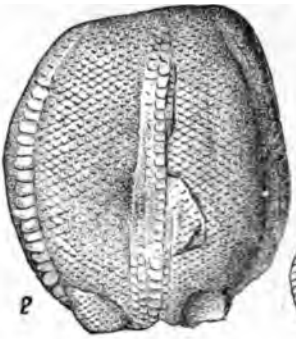
PALÆACIS CUNEATUS.

Page 369.

Fig. 8. Side view of a specimen of ordinary size.

Fig. 9. Edge view of the same; natural size.

SUB-CARBONIFEROUS.



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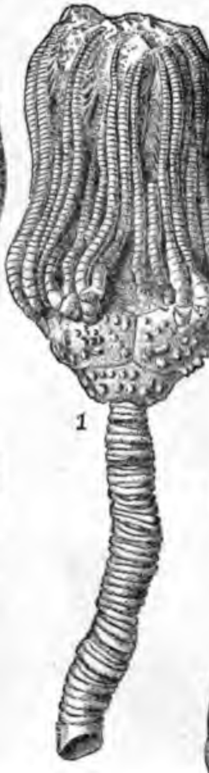

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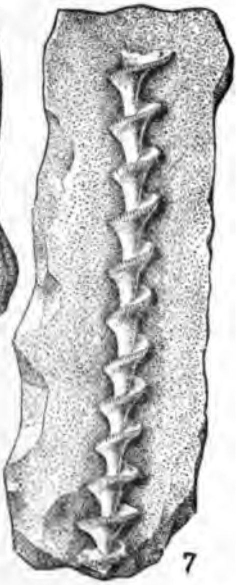

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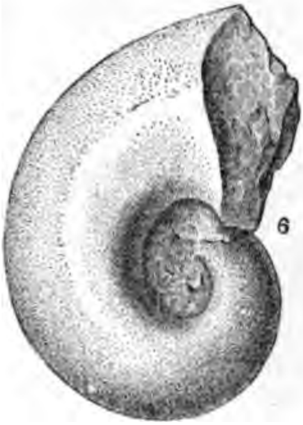

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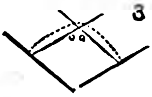

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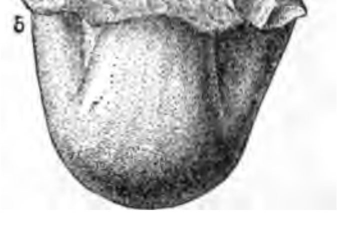

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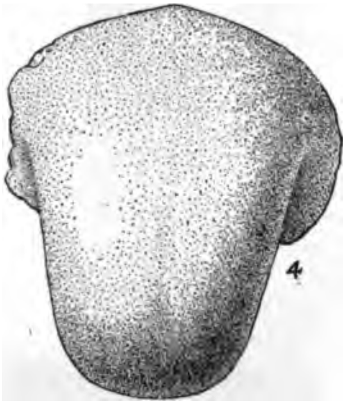

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From Pen Drawings by J. C. McConnell.

PLATE 42.*

PRODUCTUS PUNCTATUS.

Page 373.

Fig. 1. Ventral view of an adult example.
Fig. 2. Dorsal view of the same.
Fig. 3. Lateral view of the same.

SPIRIFER LINEATUS.

Page 372.

Fig. 4. Ventral view of an example of ordinary size.
Fig. 5. Dorsal view of the same.
Fig. 6. Lateral view of the same.

POLYPHEMOPSIS NITIDULA?

Page 370.

Fig. 7. Apertural view of a large example.
Fig. 8. Opposite view of the same.

NUCULA VENTRICOSA.

Page 371.

Fig. 9. Left side view of an example of ordinary size.
Fig. 10. Dorsal view of the same.

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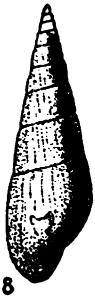
*All the figures on this plate are of natural size.



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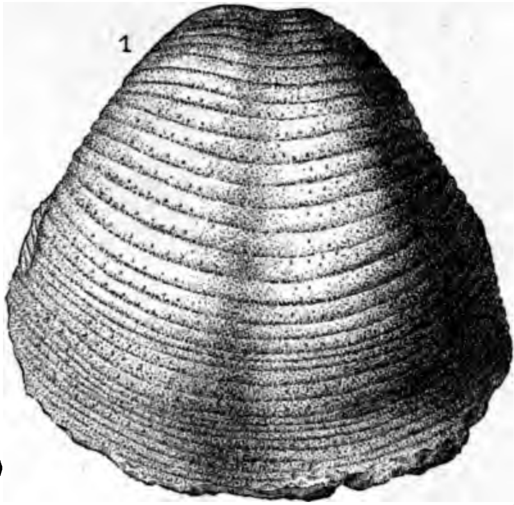

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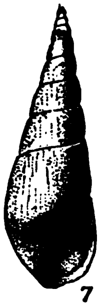

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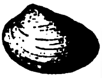

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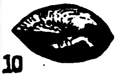

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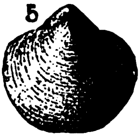

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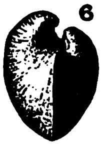

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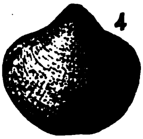

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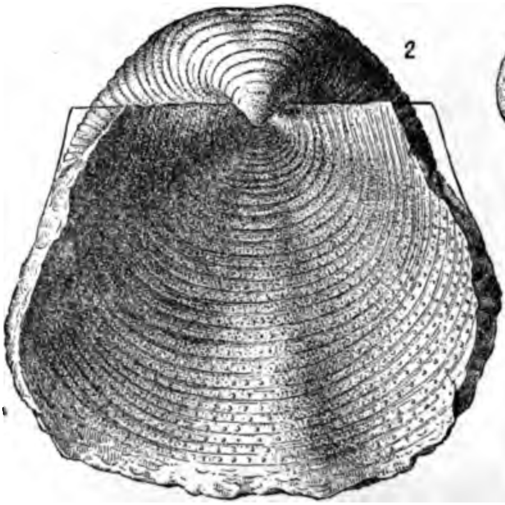

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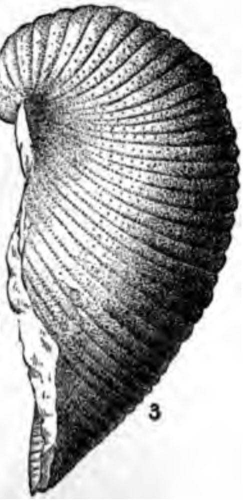

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From Pen Drawings by J. C. McConnell.

PLATE 43.*

TAONURUS COLLETTI.

Page 374.

Fig. 1. Example from Fountain County, Indiana.

SPHENOPHYLLUM SCHLOTHEIMI.

Page 374.

Fig. 2. Impression in shale of a few whorls of leaflets.

SPHENOPHYLLUM EMARGINATUM.

Page 375.

Fig. 3. Impression in shale of a few whorls of leaflets.

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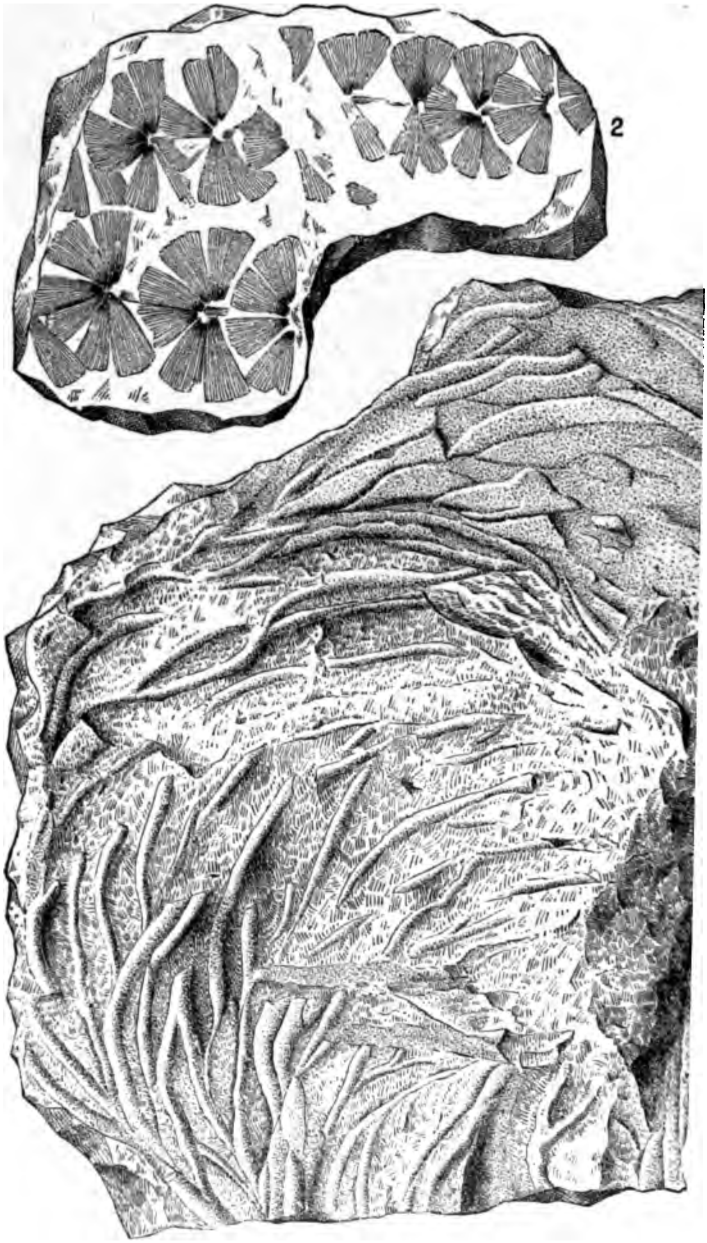
*All the figures on this plate are of natural size.



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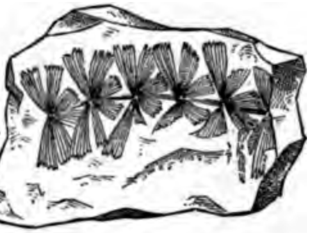

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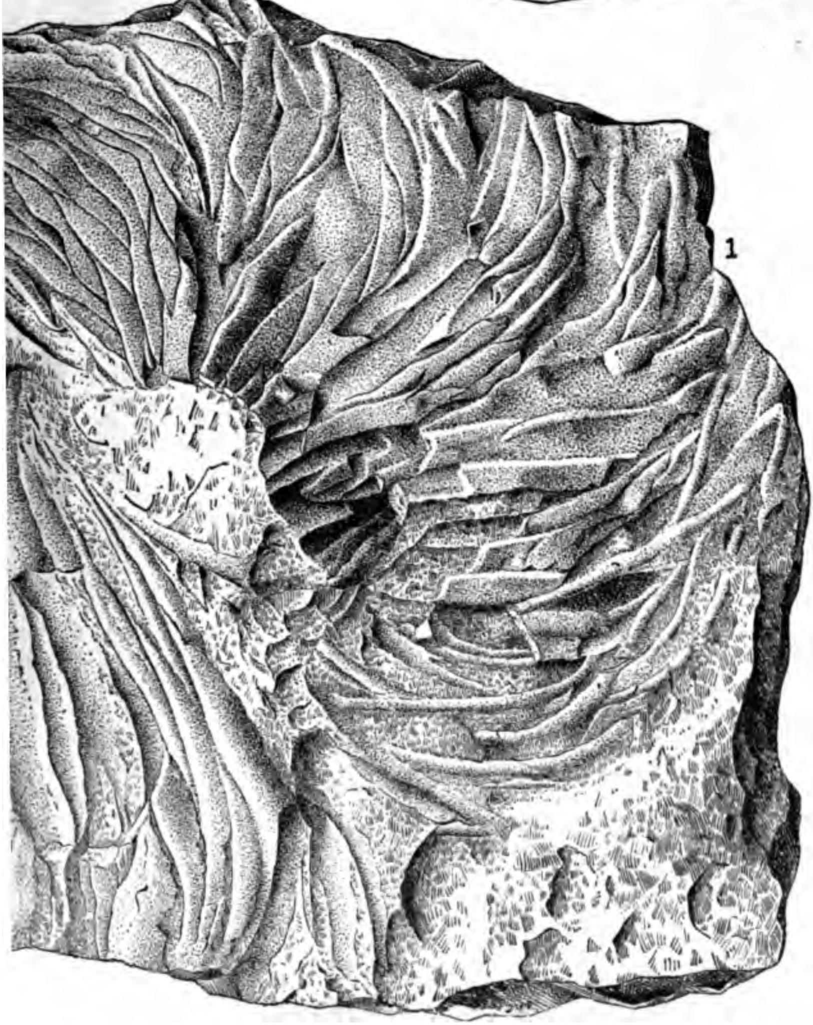

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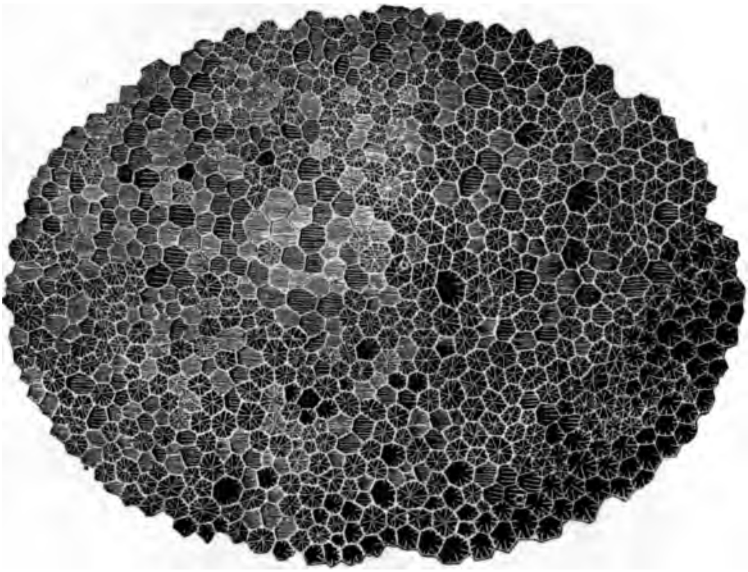
PLATE 44.

FAVISTELLA STELLATA.

Page 378.

Fig. 1. Upper view of corallum, showing mouths of the corallites.
Fig. 2. Under view of the same.



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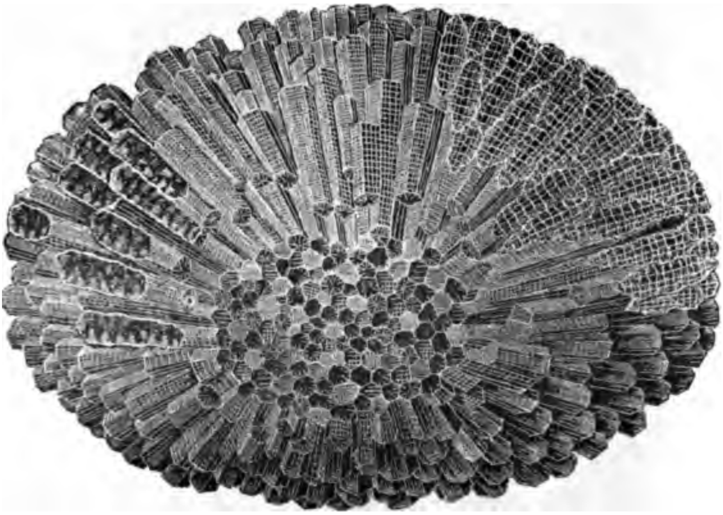

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Drawn and Engraved by J. W. Van Cleve.

PLATE 45.

AMPLEXUS YANDELLI.

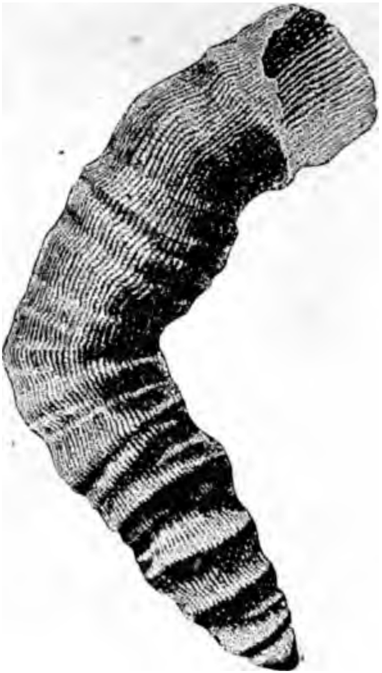
Page 393.

Fig. 1. Side view of a corallum.
Fig. 2. Longitudinal section of the same, showing tabulæ.

ZAPHRENTIS RAFINESQUI.

Page 393.

Fig. 3. Lateral view of an adult example.
Fig. 4. Similar view of a short example.
Fig. 5. Lateral view of another, the calyx being broken.



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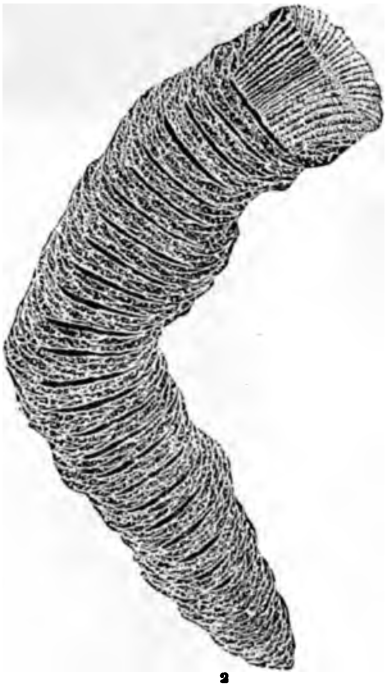

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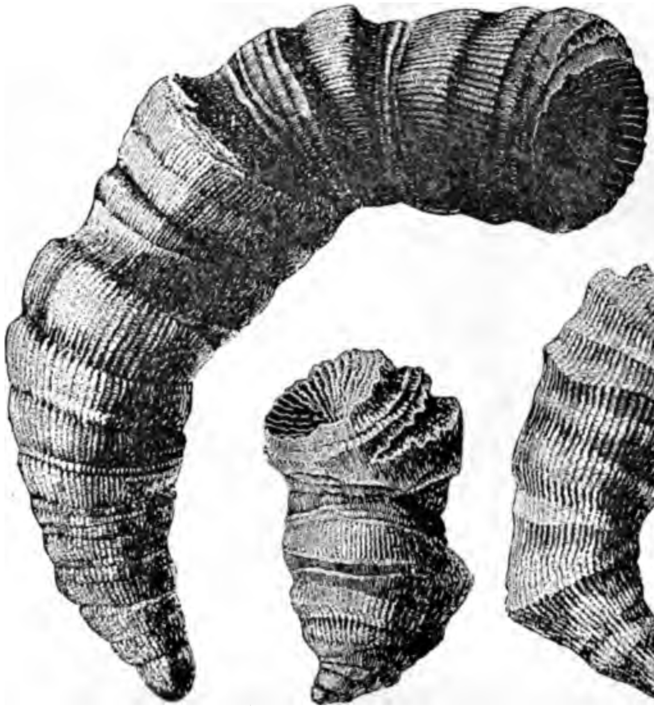

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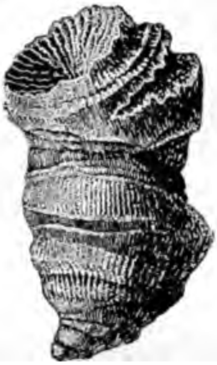

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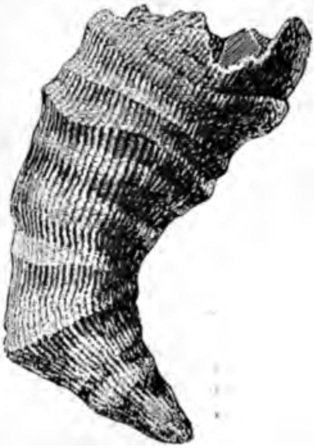

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Drawn and Engraved by J. W. Van Cleve.

PLATE 46.

CONSTELLARIA ANTHELOIDEA.

Page 379.

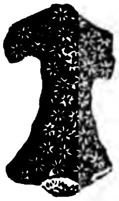
Fig. 1. Fragment of a corallum, natural size.
Fig. 2. Fragment of another example.
Fig. 3. Portion of a corallum, enlarged.

HALYSITES CATENULATA.

Page 382.

Fig. 4. Upper view of a corallum, showing open mouths of corallites.
Fig. 5. Lateral view of portion of a similar corallum.
Fig. 6. Upper view of another corallum composed of larger corallites.
Fig. 7. Lateral view of a portion of a similar corallum.

VAN CLEVE'S CORALS.



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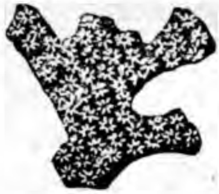

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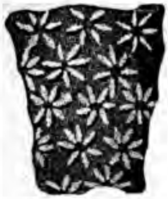

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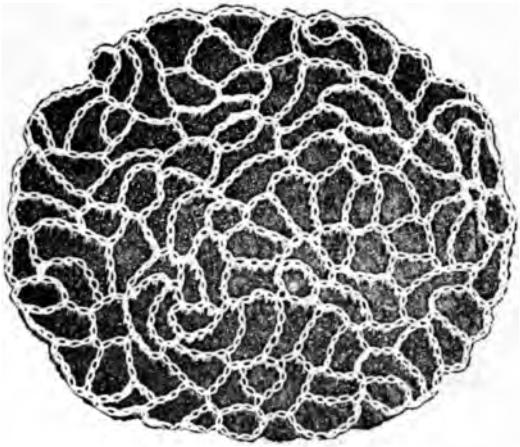

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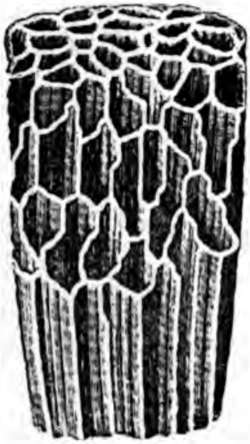

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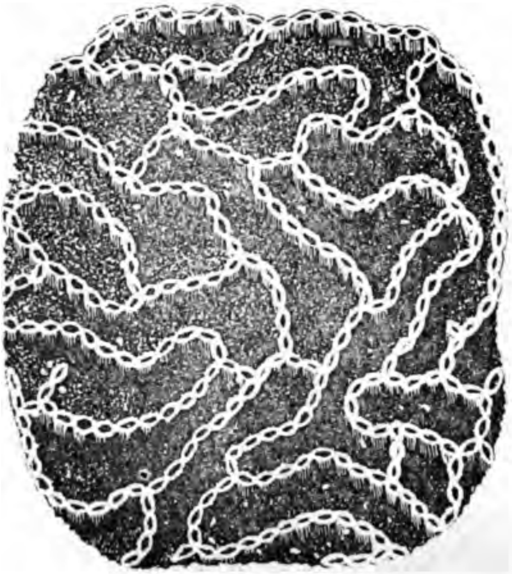

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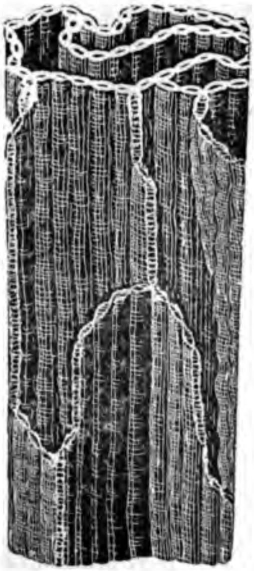

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PLATE 47.

FISTULIPORA CANADENSIS.

Page 396.

Fig. 1. Upper view of a corallum, showing mouths of corallites.
Fig. 2. Section of the same showing walls and tabulæ of the corallites, but the secondary tubulæ of the parenchyma are not well shown.

SYRINGOPORA MACLUREI.

Page 399.

Fig. 3. Lateral view of a corallum, or mass of corallites.
Fig. 4. Section of one of the corallites, showing funnel-shaped septa.

LYELLIA AMERICANA.

Page 381.

Fig. 5. Lateral view of portion of a weathered corallum.

CLADOPORA RETICULATA.

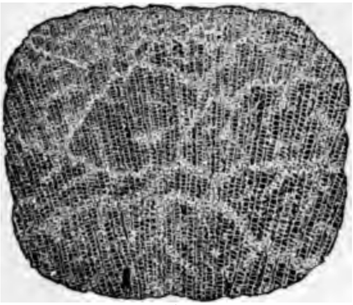
Page 384.

Fig. 6. Portion of a corallum imbedded upon a fragment of limestone.

STRIATOPORA LINNÆANA.

Page 398.

Fig. 7. Fragment of a corallum.



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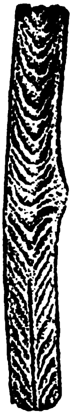

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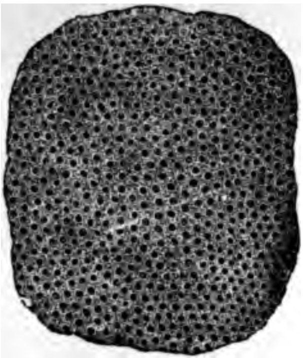

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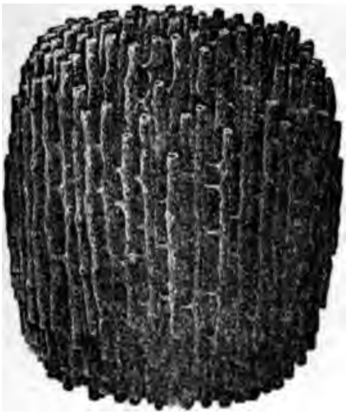

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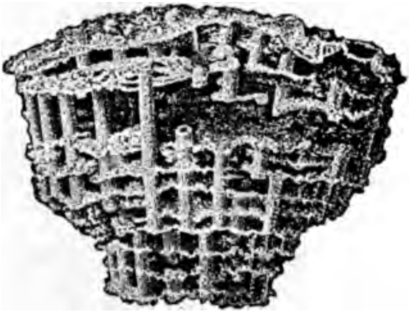

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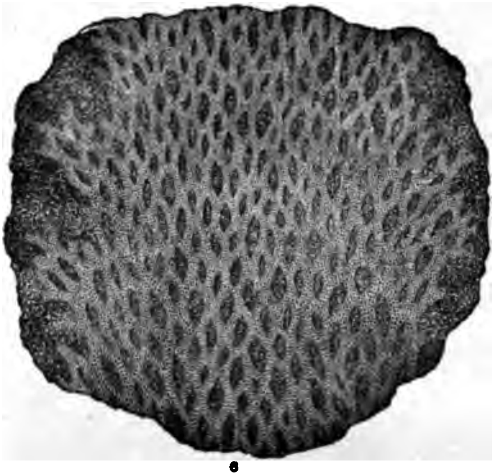

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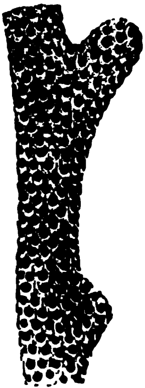

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PLATE 48.

DIPHYPHYLLUM STRAMINEUM.

Page 388.

Fig. 1. Side view of a mass of corallites.

MONTICULIPORA FRONDOSA.

Page 380.

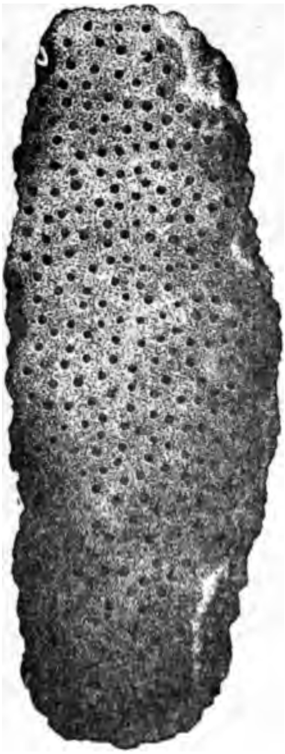
Fig. 2. Fragment of a corallum, showing mamillated surface, the fractures showing the slender corallites.

Fig. 3. Another example.

HELIOLITES ELEGANS?

Page 383.

Fig. 4. View of the upper surface of an example probably belonging to this species, but the details of the structure are not clearly shown.



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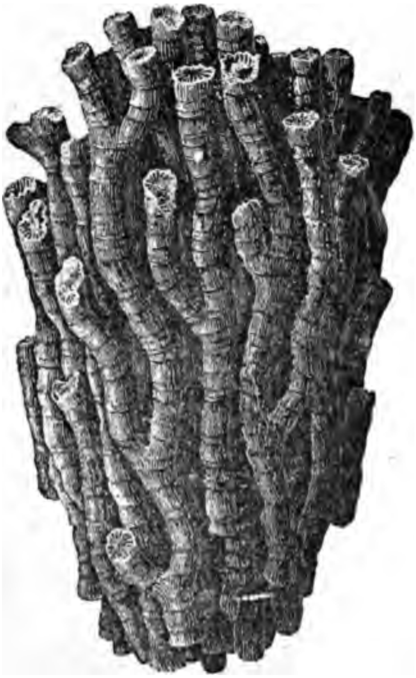

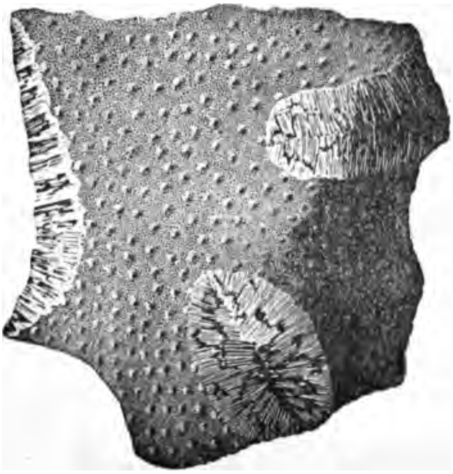

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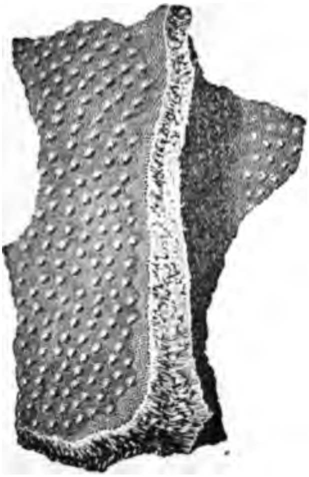

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PLATE 49.

ERIDOPHYLLUM STRICTUM.

Page 390.

Fig. 1. Side view of a small mass of corallites.

ACERVULARIA DAVIDSONI.

Page 386.

Fig. 2. Upper view of a corallum, showing calyces of the corallites.

SYRINGOPORA PERELEGANS.

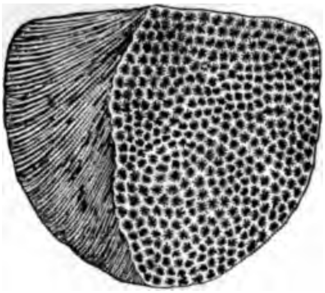
Page 398.

Fig. 3. Side view of a corallum or mass of corallites.

PROTAREA VETUSTA.

Page 378.

Fig. 4. View of a corallum encrusting the surface of the ventral valve of *Strophomena alternata*.



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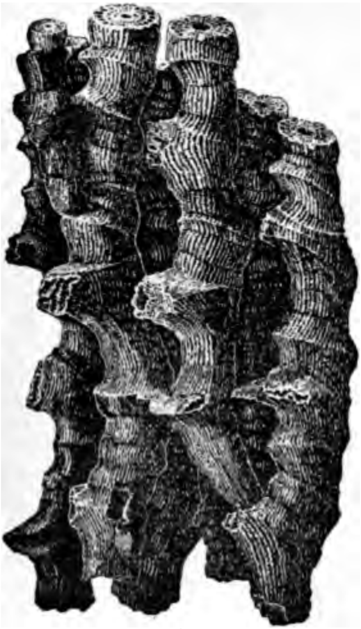

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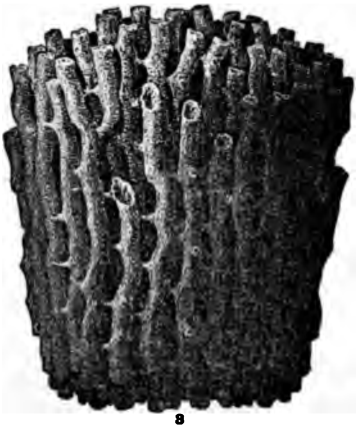

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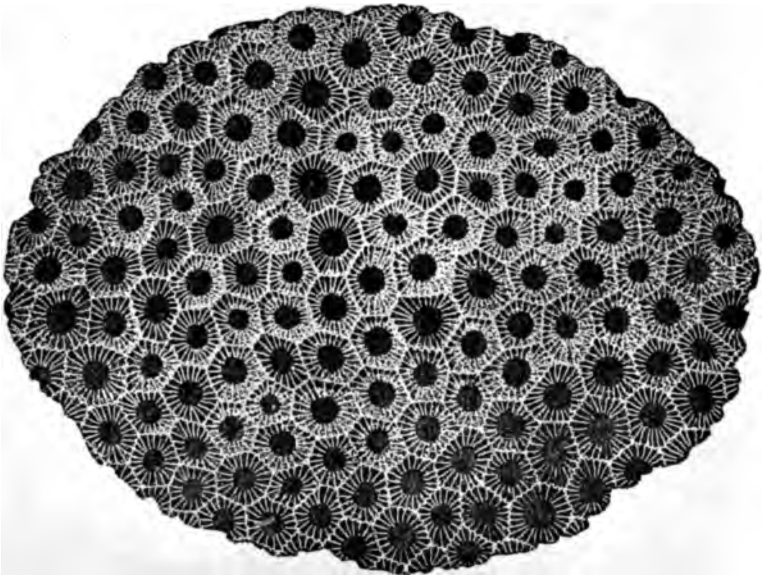

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PLATE 50.

Diphyphyllum archiaci.

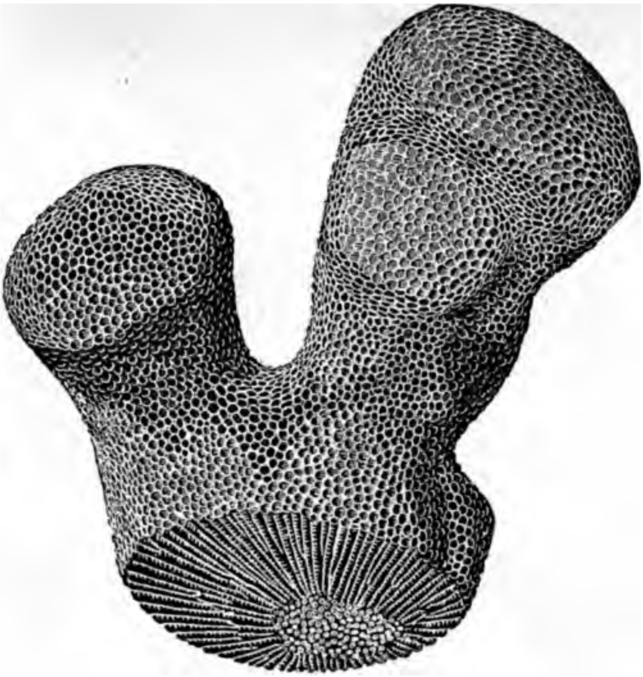
Page 387.

Fig. 1. Showing side of corallum and upper ends of corallites cut off.

Favosites polymorpha.

Page 395.

Fig. 2. Side view of a portion of a corallum. For other figures see plate 50.



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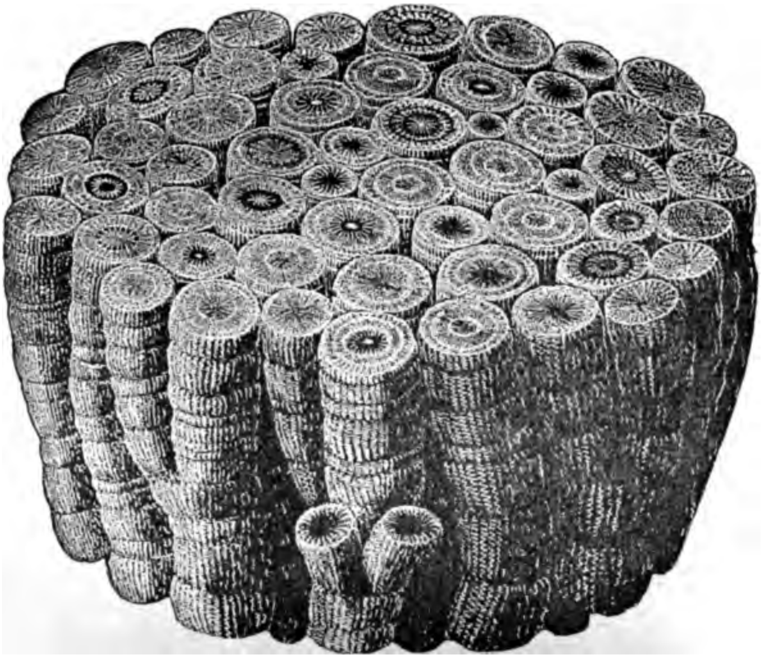

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PLATE 51.

DIPHYPHYLLUM ARUNDINACEUM.

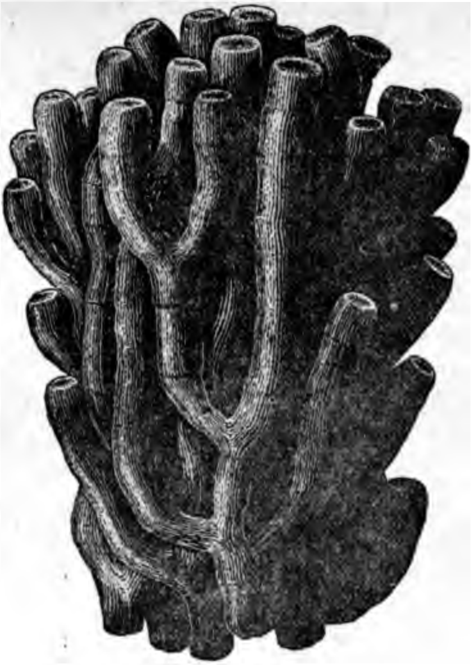
Page 389.

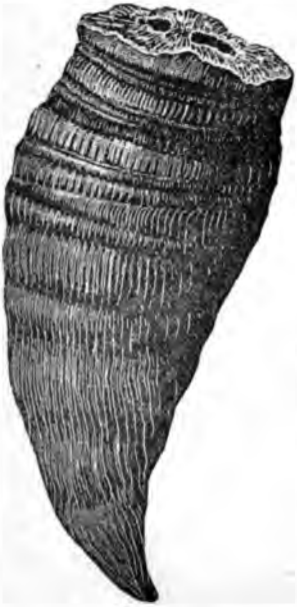
Fig. 1. Side view of a mass of corallites.

STREPTELASMA CORNICULUM.

Page 376.

Fig. 2. Side view of a corallum; the calyx broken away.
Fig. 3. Similar view of another example, similarly broken.
Fig. 4. Lower portion of another example showing septa.





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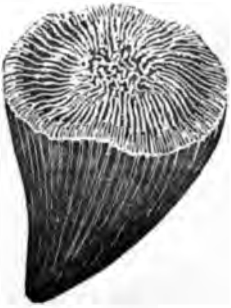

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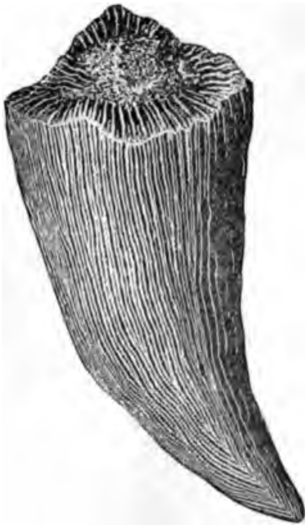

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PLATE 52.

FAVOSITES FAVOSUS.

Page 383.

Fig. 1. Upper view of a corallum, showing open mouths of the corallites.
Fig. 2. Lateral view of a few separated corallites, showing communicating mural pores.

LITHOSTROTION MAMILLARE.

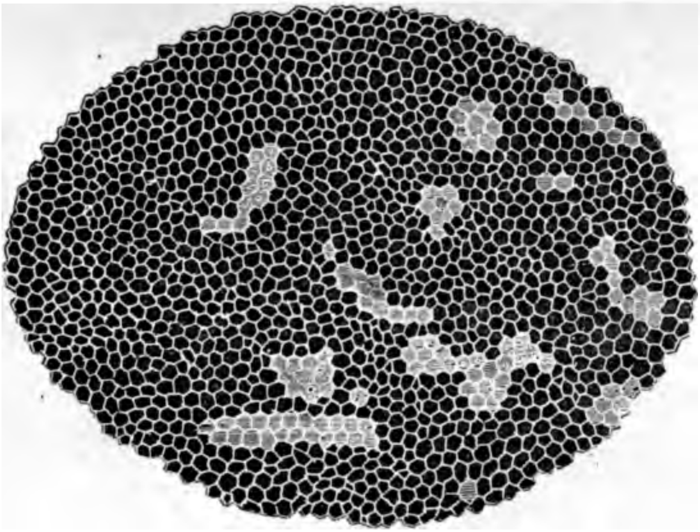
Page 401.

Fig. 3. Upper view of a corallum, showing calyces of the corallites,

PALÆOPHYLLUM DIVARICANS.

Page 377.

Fig. 4. Side view of a small group.



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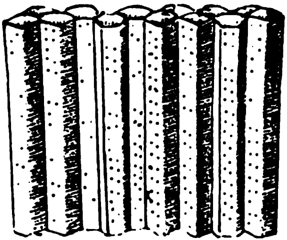

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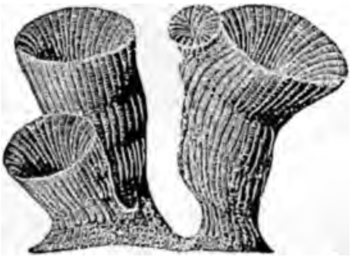

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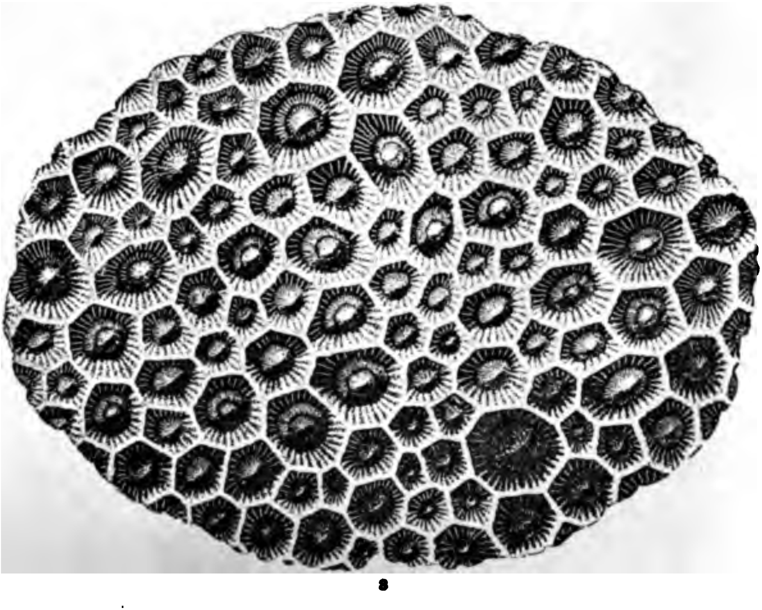

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PLATE 53.

FAVOSITES POLYMORPHA.

Page 395.

Fig. 1. Side view of a portion of a corallum.
Fig. 2. Fragment, showing the sides of a par. of the corallites. **For another** figure, see plate 50.

FAVOSITES POLYMORPHA, *var.* DUBIA.

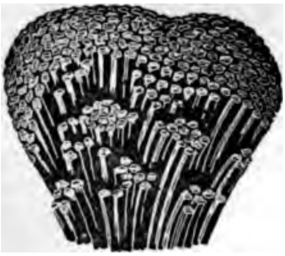
Page 396.

Fig. 3. Side view of a corallum; part of the branches broken off.

STROMATOPORA PUSTULIFERA ?

Page 400.

Fig. 4. Upper view of mass, showing pustule-like elevations.
Fig. 5. Transverse section of portion of a mass.



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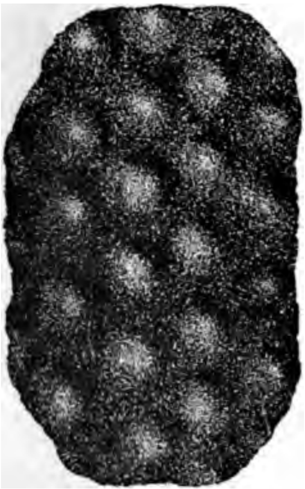

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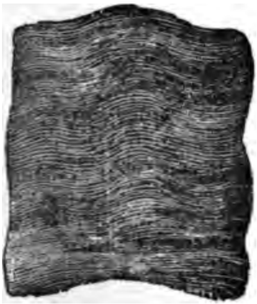

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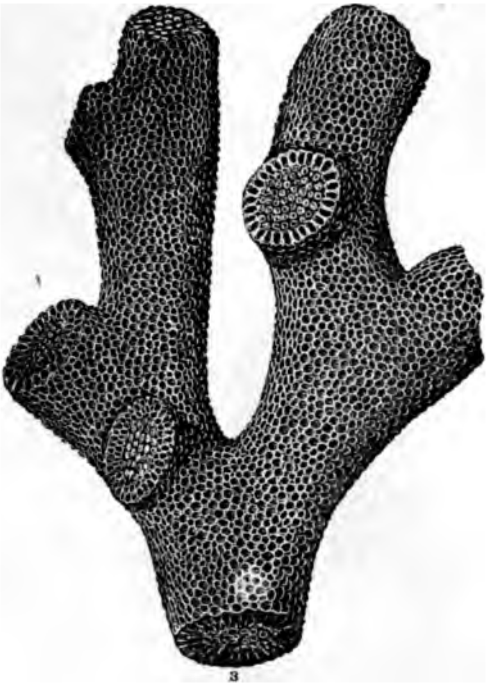

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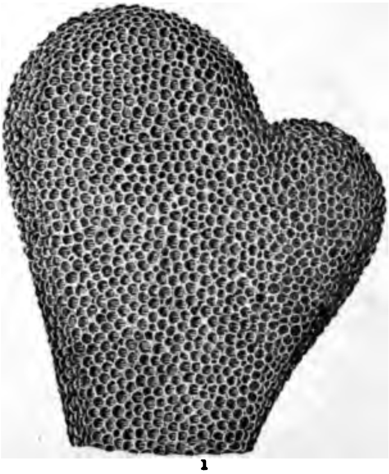

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PLATE 54.

FAVOSITES BASALTICA.

Page 394.

Fig. 1. Side view of a portion of a corallum.

FAVOSITES ———?

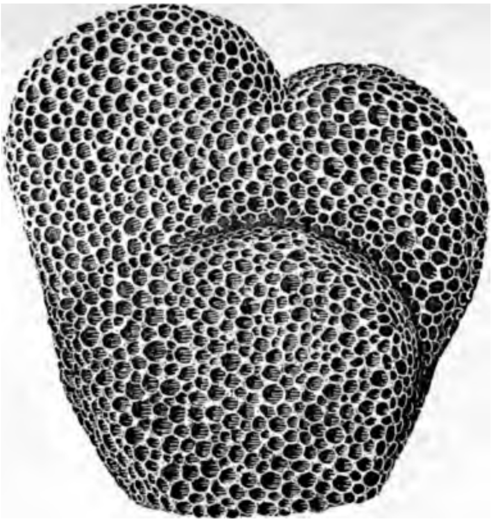
Page 396.

Fig. 2. Under view of a corallum.

ALVEOLITES GOLDFUSSI.

Page 397.

Fig. 3. Upper view of a corallum.



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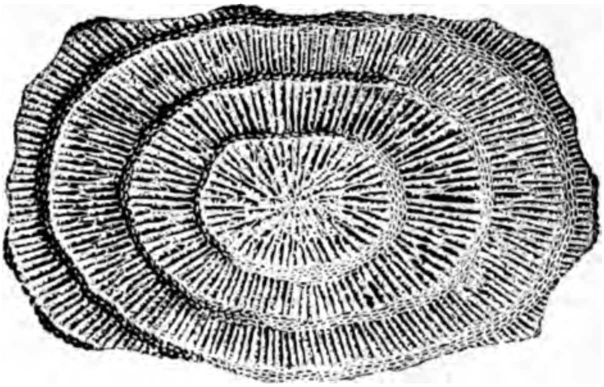

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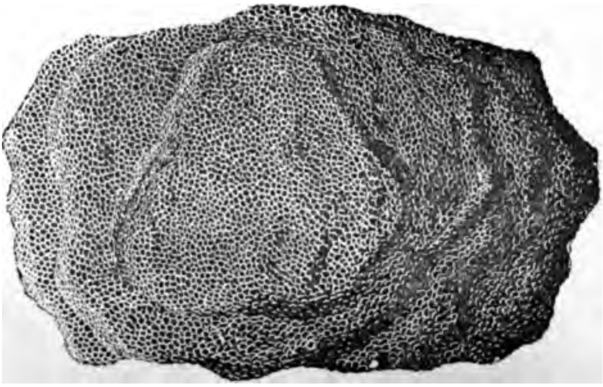

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PLATE 55.

CYSTIPHYLLUM VESICULOSUM.

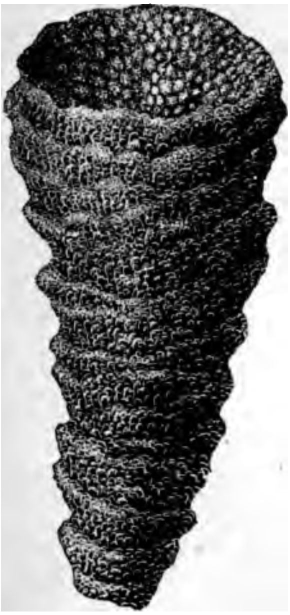
Page 391.

Fig. 1. Side view of a corallum.
Fig. 2 Similar view of another example.

CLATHROPORA FRONDOSA.

Page 385.

Fig. 3. Portion of a large frond or polypidom imbedded upon a piece of limestone.



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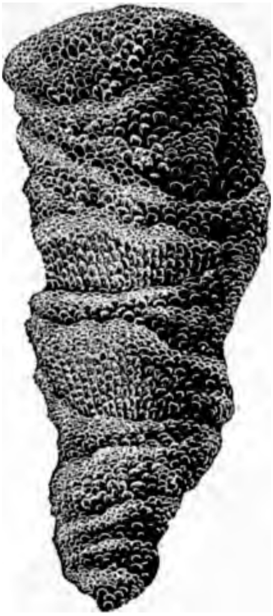

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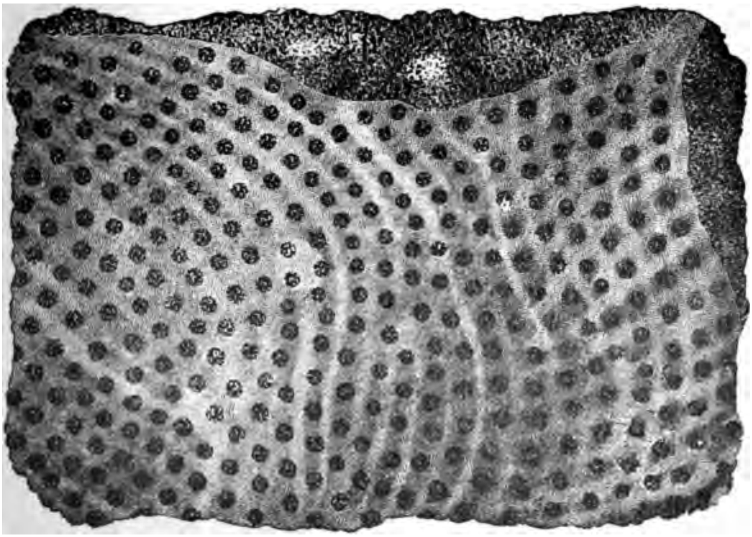

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